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(2)

GENERALIZED COMPUTER PROGRAM

STREAMFLOW ROUTING OPTIMIZATION

(OPROUT)

USERS MANUAL

JANUARY 1982

HEC HYDROLOGIC ENGINEERING CENTER

Water Resources Support Center U.S. Army Corps of Engineers

DRAFT

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(OPROUT)

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The Hydrologic Engineering Center

INTRODUCTION

1. ORIGIN OF PROGRAM

The computer program "Streamflow Routing Optimization" (OPROUT) was developed at the Hydrologic Engineering Center (HEC) by Vernon R. Bonner. The program consists of optimization routines developed originally by Dr. Anthony Slocum and Ramesk Danekar of Anderson-Nichols & Company, Inc., as a portion of HEC contract, "Evaluation of Streamflow Routing Techniques with Special Emphasis on Determining Nonlinear Routing Criteria," October 1975, (Contract No. DACW05-75-C-0027). These routines were linked with routing and plotting routines from the computer program HEC-5, "Simulation of Flood Control and Conservation Systems," into one program, OPROUT, which this manual describes.

2. PURPOSE OF PROGRAM

This program can be used to determine Modified Puls or Muskingum routing criteria by optimizing parameters for a single reach using observed upstream and downstream hydrographs for one to five events. The main advantage to the program is that the user can develop routing criteria from several events by making one computer program execution.

3. TECHNICAL APPROACH

a. Modified Puls Routing Method. In this routing method, outflow is a unique function of storage. The following relationships apply:

$$\frac{\Delta S}{\Delta t} = I - 0 \qquad (1)$$

where

I = average inflow in the reach during time interval Δt

0 = average outflow from the reach during time interval Δt

ΔS = change in storage during time interval Δt

$$0 = \frac{0_1 - 0_2}{2} \qquad (2)$$

where 0_1 and 0_2 = reach outflow at start and end of time interval, respectively

$$\Delta S = \frac{S_2 - S_1}{2} \qquad (3)$$

where S_1 and S_2 = reach storage at start and end of time interval, respectively

substituting (2) and (3) in (1) and rearranging,

$$\frac{S_2}{\Delta t} + \frac{0_2}{2} = \frac{S_1}{\Delta t} - \frac{0_1}{2} + I \qquad (4)$$

Let $SI = S + \frac{0}{2}$ = storage indication and $\Delta t = 1$ then,

$$SI_2 = SI_1 + I - 0_1 \qquad (5)$$

equation (5) can be solved using a storage indication-outflow (SI vs 0) relationship and knowing reach inflow.

^- ~an be seen from the described relationships, modified Puls routing requires a storage-outflow relationship for the downstream end of the routing reach. The relation indicates the amount of flow occurring at the downstream end of the reach for a given amount of water stored in the reach between the upstream and downstream ends.

Starting with the given information, an observed hydrograph at the upstream end of the reach and an observed hydrograph at the downstream end of the reach, the problem is associated with defining the proper storage-outflow relationship. The proper relationship when used with modified Puls routing will generate a routed hydrograph (observed upstream hydrograph routed to the downstream end) which is the same as would occur in the real river reach. If there were zero local flows, the routed hydrograph would be equal to the observed downstream hydrograph. In reality there will be local flow entering the reach during at least part of the time period of the observed hydrographs. If this local flow was gaged (all local flow coming from a gaged tributary), the local flow could be subtracted from the downstream observed hydrograph. The result would provide the upstream routed hydrograph. Unfortunately, in the majority of cases, the local flow is ungaged and not known. In this situation, the observed upstream hydrograph can be routed to the downstream end and subtracted from the observed downstream hydrograph to generate the local flow hydrograph. If the routed hydrograph is reasonable, no negative local flows will be generated by this procedure (i.e., for all time periods, the routed hydrograph is always less than or equal to the downstream observed hydrograph). This fact is used to form the objective function for the optimization routine. It is stated:

Objective Function - Minimize the Sum of Negative Local Flow in a given routing reach by proper defintion of the storage-outflow relationship and number of routing subreaches using Modified Puls with upstream and downstream observed hydrographs.

One form for the storage-outfl- relationship is as follows:

$$S = KO^M \tag{6}$$

where

S = total sotrage in the routing reach

O = reach outflow

K, M = are constants which cause the function to represent the storage-outflow relationship of the river reach under study

With this function a gradient search approach can be used to achieve the stated objective function. Computationally, a beginning K and M are selected from the observed hydrograph information (M = 1 and K equal travel time of peak flow). The number of subreaches is set to one. A modified Puls routing is performed based upon the selected $S = KO^M$ function. The routed hydrograph is subtracted from the observed downstream hydrograph which determines the sum of the negative local flow. Either K or M is changed following a gradient search procedure and a new sum negative local flow is computed which can be compared to the last value. This procedure is continued until the objective function can no longer be improved. The number of routing subreaches is incremented by one and the gradient search procedure is continued. The result provides the optimum K, M and number of subreaches for the given routing reach with the given observed hydrograph. The selected exponent usually is in the

following range:

$$0.6 < M < 0.8$$

and the number of subreaches usually equals 2.

A curve warping routine was written to overcome the computational difficulty and the inflexibility of using only $S = KO^M$ to represent storage-outflow. This routine is very simple and surprisingly effective.

The optimization routine still begins with a macro gradient search $S = KO^M$ to obtain a beginning storage-outflow function which is reasonable. Then the curve warping routine is called. The computed storage-outflow relationship is divided into 17 piece-wise linear segments (this is also used in other HEC programs using modified Puls). This forms a table of storage versus outflow for equally spaced flow segments starting at zero and ending at the peak flow of the observed downstream hydrograph. The number of segments can be input by the user up to a maximum of 18 segments.

The curve warping routine works in the following manner. One cycle consists of testing each point in the storage-outflow table beginning with the lowest point above zero. The flow is held constant and the storage is stepped up, down or not changed depending if the objective function is improved. Storage is never stepped greater than the value for the next higher point in the table or less than the next lower point in the table to keep the function single valued. If an improvement was made during the last cycle, a new cycle is performed. This is continued until no more improvement can be obtained. The step size is reduced and the process is repeated. When no more improvement can be be made, the number of subreaches is incremented by one and the curve warp routine is recalled. The final result provides the optimum number of subreaches and the storage-outflow function. The several additional degress of freedom in this function enable a solution which works well for all magnitudes of flood events within those used to derive the storage-outflow relationship.

The program also employs an optional curve fit routine for smoothing the developed storage-outflow function after the curve warping routine. The program also incorporates several other components of the objective function described previously to improve the reasonableness of the local flow hydrograph and to force the routed hydrograph toward the recession side of the given, observed downstream hydrograph. The total routing objective function is defined as follows;

MINIMIZE SUMNL = SUM (SUM1 + SUM2 + SUM3) (7)

where the three components are defined as,

1) For all time periods,

SUM1 = SUM (negative local flows) * WT1

2) For the recession limb of the routed hydrograph defined as from 85% of the routed hydrograph peak discharge to 15% of the observed downstream hydrograph peak discharge, and where the routed flow is less than 95% of the observed downstream flow (indicating how early this portion of the routed hydrograph is),

SUM2 = SUM (routed hydrograph minus observed downstream hydrograph) * WT2

and 3) For all time periods following the peak discharge of the routed hydrograph (indicating how late this portion of the routed hydrograph is),

SUM3 = SUM (negative local flows) * WT3

Weighting of the individual components of the objective function (WT1, WT2 and WT3) can be input by the user on the RT card as described in Exhibit 2, Input Description. One or both of the second (SUM2) and the third (SUM3) can be eliminated by default values of zero for WT2 and/or WT3 thereby changing the basis of the objective function. The program output lists the value (error)

of each of the three components and the total (SUM1, SUM2, SUM3 and SUMNL) for each iteration as NEG LOCAL, TOO EARLY, TOO LATE and TOTAL, respectively.

b. Muskingum Routing Method. In this method, outflow from a routing reach is a linear function of the sum of prism and wedge storage in the reach. The basic routing equation is:

$$O_n = C_1 I_n + C_2 I_{n-1} + C_3 I_{n-2} \ldots \quad (8)$$

where:

O_n = Ordinate of outflow hydrograph at time n

I_n, I_{n-1}, etc. = Ordinates of inflow hydrograph at times n, n-1, etc.

C_1, C_2, etc. = Routing coefficients, as coefficients of inflow

Equations used to determine the coefficients C_1, C_2, etc., are as follows:

$$C_1 = (\Delta t - 2XK) / (2 K(1-X) + \Delta t) \quad (9)$$

$$CC = ((2K(1-X) + \Delta t) - 2\Delta t)/(2K(1-X) + \Delta t) \quad (10)$$

$$C_2 = C_1 \cdot CC + (\Delta t + 2KX) / (2K(1-X) + \Delta t) \quad (11)$$

$$C_i = C_{i-1} \cdot CC \text{ for } i > 2 \quad (12)$$

where

Δt = Routing time increment

K = Muskingum routing parameter having units of time

X = Muskingum dimensionless routing parameter between 0 and .5

The program has the capability of optimizing Muskingum routing coeffici·· using the same techniques and search procedures as described for the modified Puls method. The M in equation (6) is equal to 1 for the linear Muskingum method and the same objective function is used to optimize Muskingum routing constants and K and X.

From the above relationships it can be seen that the following relationship between K for each subreach and Δt must be true to avoid negative coefficients.

$$\frac{1}{2(1-X)} \leq \frac{K}{\Delta t} \leq \frac{1}{2X}$$

If a Muskingum routing optimization produces negative coefficients, the user should increase the number of subreaches, thereby reducing K, so that the above limits are met. The method for defining the number of subreaches (RT.3, 3rd field of the RT Card) is described under paragraph 4, Program Capabilities and illustrated in Exhibit 1.

4. PROGRAM CAPABILITIES

The program will provide solutions to the following problems:

a. Determine Muskingum K and X and the number of routing subreaches for a single reach with up to five sets of given upstream and downstream observed hydrographs. Each hydrograph set is given equal weight in the optimization objective function.

b. Determine Modified Puls storage-outflow relationship and number of routing subreaches for a given reach with up to five multiple sets of given upstream and downstream observed hydrographs.

c. Determine routing criteria for a given number of subreaches in either cases a or b above.

d. Determine the storage-outflow curve, as in case b above, with a given coefficient X (Working R&D routing) or an additional lag of the routed hydrograph.

Under any of the above options, a complete trace feature is available to monitor the progress of the optimization computations. This feature is written in the same manner as exists in HEC-5; therefore, a source listing is required to interpret results.

The program can be used to solve the more difficult problem when two or more upstream gages and routing reaches flow to a common downstream gage. This currently cannot be solved automatically by the program; however, the user can develop routing criteria for this situation by multiple executions of the current program. In most cases, one upstream gage will have the dominant flow. The optimization routine can be operated using the dominant upstream gage as the observed upstream hydrograph and the given observed downstream hydrograph. The resulting local flow hydrograph which is computed by the Optimization Routine can be used as the observed downstream hydrograph in conjunction with the next largest upstream gage flow which becomes the observed upstream hydrograph.

This process is repeated until routing criteria is defined for all routing reaches. In most cases, some user smoothing of the local flow hydrographs will be required (while maintaining consistent volume) and a second iteration will be required beginning with the dominant upstream gage. The problem is difficult to solve due to the many additional degress of freedom. For each additional routing reach, two basic unknowns are added, routing criteria and local flow; whereas, only one known is added, upstream observed hydrograph.

During the performance of the optimization routine, a printer plot can be requested (5th field of J1 card) which will plot the upstream observed hydrograph (values entered on IN cards), downstream observed hydrograph (values entered on IN cards), routed hydrograph (upstream hydrograph routed to downstream location using routing criteria derived by optimization routine) and the computed local flow hydrograph (difference between routed hydrograph and downstream observed hydrograph). This provides a visual check on the results developed by the optimization subroutine.

In addition, upon completion, the optimization routine prints the values for the adopted storage-outflow relationship (table of storage versus flow) and the optimum number of subreaches. The travel time indicator (inverse slope of storage-outflow relationship) is also printed for each incremental linear segment of the storage-outflow table and for the given point to the origin. The upstream hydrograph is printed as read in addition to the routed hydrograph. Incremental local flows are printed twice for each control point. The first is the computed values without adjustment and the second is the adjusted values with all computed negative values set to zero. The negative volume is proportioned to the remaining positive values. Program capabilities are illustrated in Exhibit 1 - Example Input and Output. A detailed description of the program input is presented in Exhibit 2.

EXHIBIT 1

EXAMPLE INPUT AND OUTPUT

EXHIBIT 1

EXAMPLE INPUT AND OUTPUT

Streamflow Routing Optimization (OPROUT)

The input and output for three examples are provided to illustrate the use of selected program capabilities and options and to assist in verifying the correct execution of the program. A brief description of each example is provided below. Printer plots are requested for each of the examples.

a. Example 1 - To determine modified Puls storage-outflow relationship and the number of routing subreaches for a single reach and from a single flood event.

b. Example 2 - To determine modified Puls storage-outflow relationship and the number of routing subreaches using three flood events. (J1.7)

c. Example 3 - To determine Muskingum K and X for one flood event and a user specified number of routing subreaches. (RT.3)

EXAMPLE 1 INPUT

```
T1EXAMPLE 1 MODIFIED PULS ROUTING OPTIMIZATION
T2    SCIOTO RIVER  CHILLICOTHE TO HIGBY OHIO
T3    SINGLE EVENT - JANUARY 1959
J1    100       3       0       0       1       0       0       0       1       1
ID CHILLICOTHE TO HIGBY - JAN 1959
RT      2       3      .5       0       0       0       6       3       3       0
IN      2   JAN59
QO   3160    3093    3025    2940    3020    3207    3800    4660    5650    7203
QO   8395    9653   11400   13300   15200   17075   18600   20150   21700   23575
QO  25800   31250   42800   64650   99900  126000  140000  143000  138000  130500
QO120500   110500  103000   94300   85500   76950   69000   63100   57200   52350
QO  47500   43950   40400   37300   34200   31750   29300   27550   25800   24450
QO  23100   22000   20900   19950   19000   18300   17600   17150   16700   16500
QO  16300   16225   16150   16075   16000   15900   15800   15650   15500   15300
QO  15100   14800   14500   14125   13750   13375   13000   12725   12450   12175
QO  11900   11600   11300   11000   10750   10500   10250   10000    9750    9500
QO   9250    9000    8750    8500    8250    8000    7750    7500    7250    7000
IN      3   JAN59
QO   4580    4449    4317    4277    4420    5850    7635    9595   11800   14500
QO  17750   21450   25200   28125   31550   35000   37900   39580   41450   42975
QO  44700   47050   49400   53300   59400   74850   97350  121000  143000  156500
QO160000   157000  149000  138000  127000  115000  103000   93200   83400   76850
QO  70300   64950   59600   55550   51500   47750   44000   40750   37500   34950
QO  32400   29850   27300   26000   24700   23400   22100   21300   20500   20000
QO  19500   19200   19025   18912   18800   18300   18300   18300   18300   18300
QO  18300   18300   18300   15700   15700   15700   15700   15700   15700   15700
QO  15700   13100   13100   13100   13100   13100   13100   13100   13100   11200
QO  11200   11200   11200   11200   11200   11200   11200    8600    8600    8600
```

EXAMPLE 1 OUTPUT

```
ROUTING OPTIMIZATION INPUT DATA

T1EXAMPLE 1 MODIFIED PULS ROUTING OPTIMIZATION
T2    SCIOTO RIVER  CHILLICOTHE TO HIGBY OHIO
T3    SINGLE EVENT - JANUARY 1959

          NPER       IPER      INPUT      IPRNT      IPLOT     IPUNCH     NFLOOD      NPTSQ      ICURV      IFLOW
J1         100          3          0          0          1          0          0          0          1          1

ID CHILLICOTHE TO HIGBY - JAN 1959

          RTFR       RTTO       RTMD      RTCOF      XMUSK        LAG        WT1        WT2        WT3     METRIC
RT        2.00       3.00        .50         0.         0.         0.       6.00       3.00       3.00         0.
IN           2      JAN59
   3160.00    3093.00    3025.00    2940.00    3020.00    3207.00    3800.00    4660.00    5650.00    7203.00
   8395.00    9653.00   11400.00   13300.00   15200.00   17075.00   18600.00   20150.00   21700.00   23575.00
  25800.00   31250.00   42800.00   64650.00   99900.00  126000.00  140000.00  143000.00  138000.00  130500.00
 120500.00  110500.00  103000.00   94300.00   85500.00   76950.00   69000.00   63100.00   57200.00   52350.00
  47500.00   43950.00   40400.00   37300.00   34200.00   31750.00   29300.00   27550.00   25800.00   24450.00
  23100.00   22000.00   20900.00   19950.00   19000.00   18300.00   17600.00   17150.00   16700.00   16500.00
  16300.00   16225.00   16150.00   16075.00   16000.00   15900.00   15800.00   15650.00   15500.00   15300.00
  15100.00   14800.00   14500.00   14125.00   13750.00   13375.00   13000.00   12725.00   12450.00   12175.00
  11900.00   11600.00   11300.00   11000.00   10750.00   10500.00   10250.00   10000.00    9750.00    9500.00
   9250.00    9000.00    8750.00    8500.00    8250.00    8000.00    7750.00    7500.00    7250.00    7000.00
IN           3      JAN59
   4580.00    4449.00    4317.00    4277.00    4420.00    5850.00    7635.00    9595.00   11800.00   14500.00
  17750.00   21450.00   25200.00   28125.00   31550.00   35000.00   37900.00   39580.00   41450.00   42975.00
  44700.00   47050.00   49400.00   53300.00   59400.00   74850.00   97350.00  121000.00  143000.00  156500.00
 160000.00  157000.00  149000.00  138000.00  127000.00  115000.00  103000.00   93200.00   83400.00   76850.00
  70300.00   64950.00   59600.00   55550.00   51500.00   47750.00   44000.00   40750.00   37500.00   34950.00
  32400.00   29850.00   27300.00   26000.00   24700.00   23400.00   22100.00   21300.00   20500.00   20000.00
  19500.00   19200.00   19025.00   18912.00   18800.00   18300.00   18300.00   18300.00   18300.00   18300.00
  18300.00   18300.00   18300.00   15700.00   15700.00   15700.00   15700.00   15700.00   15700.00   15700.00
  15700.00   13100.00   13100.00   13100.00   13100.00   13100.00   13100.00   13100.00   13100.00   11200.00
  11200.00   11200.00   11200.00   11200.00   11200.00   11200.00   11200.00    8600.00    8600.00    8600.00
```

OPTIMIZATION ROUTINE OUTPUT

NEG LOCAL	COMPUTED ERRORS: TOO EARLY	TOO LATE	TOTAL
0.	-33895.69	0.	-33895.69
0.	-14838.74	0.	-14838.74
-595.37	0.	-297.69	-893.06
-68706.87	0.	-34353.43	-103060.30
-47353.07	0.	-23676.54	-71029.61
0.	-14405.10	0.	-14405.10
-68706.87	0.	-34353.43	-103060.30
0.	-14838.74	0.	-14838.74
-595.37	0.	-297.69	-893.06
-4572.76	0.	-2286.38	-6859.13
-80937.04	0.	-40468.52	-121405.55
0.	-4046.71	0.	-4046.71
-7062.22	0.	-3531.11	-10593.33
0.	-39056.15	0.	-39056.15
-4572.76	0.	-2286.38	-6859.13
0.	-44886.79	0.	-44886.79
-7062.22	0.	-3531.11	-10593.33
0.	-39056.15	0.	-39056.15
-1716.79	0.	-858.39	-2575.18
-3102.68	0.	-1551.34	-4654.02
-10544.82	0.	-5272.41	-15817.23
-31181.53	0.	-15590.76	-46772.29
-20631.11	-14354.03	-10315.55	-45300.68
-23523.81	0.	-11761.90	-35285.71
-46611.07	-19877.03	-23305.53	-89793.63
0.	-1437.73	0.	-1437.73
-844.79	0.	-422.40	-1267.19
-304.40	-78335.42	-152.20	-78792.02
-813.74	0.	-406.87	-1220.61
-378.71	0.	-189.35	-568.06
-1417.03	0.	-708.51	-2125.54
-1019.76	0.	-509.88	-1529.64
-774.39	-401.72	-387.20	-1563.31
-7.44	0.	-3.72	-11.16
-1794.99	0.	-897.49	-2692.48
0.	0.	0.	0.
0.	0.	0.	0.
0.	0.	0.	0.
0.	0.	0.	0.

STORAGE-OUTFLOW FUNCTION, UNSMOOTHED

SUM OF COMPUTED ERRORS = 0.

ADOPTED STORAGE-OUTFLOW TABLE — TRAVEL TIME INDICATOR(K=STORAGE/DISCHARGE*0.08264)

DISCHARGE CFS	STORAGE ACRE-FEET	INCREMENTAL K HOURS	TOTAL K HOURS
0.	0.		
20000.00	17584.07	10.6	10.6
40000.00	35659.07	10.9	10.8
60000.00	55609.26	12.1	11.2
80000.00	72313.71	10.1	10.9
100000.00	90796.45	11.2	11.0
120000.00	112771.07	13.3	11.4
140000.00	131972.49	11.6	11.4
160000.00	151229.04	11.7	11.4

STORAGE-OUTFLOW FUNCTION, SMOOTHED

COMPUTED ERRORS:

NEG LOCAL	TOO EARLY	TOO LATE	TOTAL
0.	0.	0.	0.

SMOOTHED BY 4TH ORDER POLYNOMIAL AS FOLLOWS:

```
S =  -.2355E+03 Q**0
      .9422E+00 Q**1
     -.1643E-05 Q**2
      .2123E-10 Q**3
     -.6723E-16 Q**4
```

ADOPTED STORAGE-OUTFLOW TABLE — TRAVEL TIME INDICATOR(K=STORAGE/DISCHARGE*0.08264)

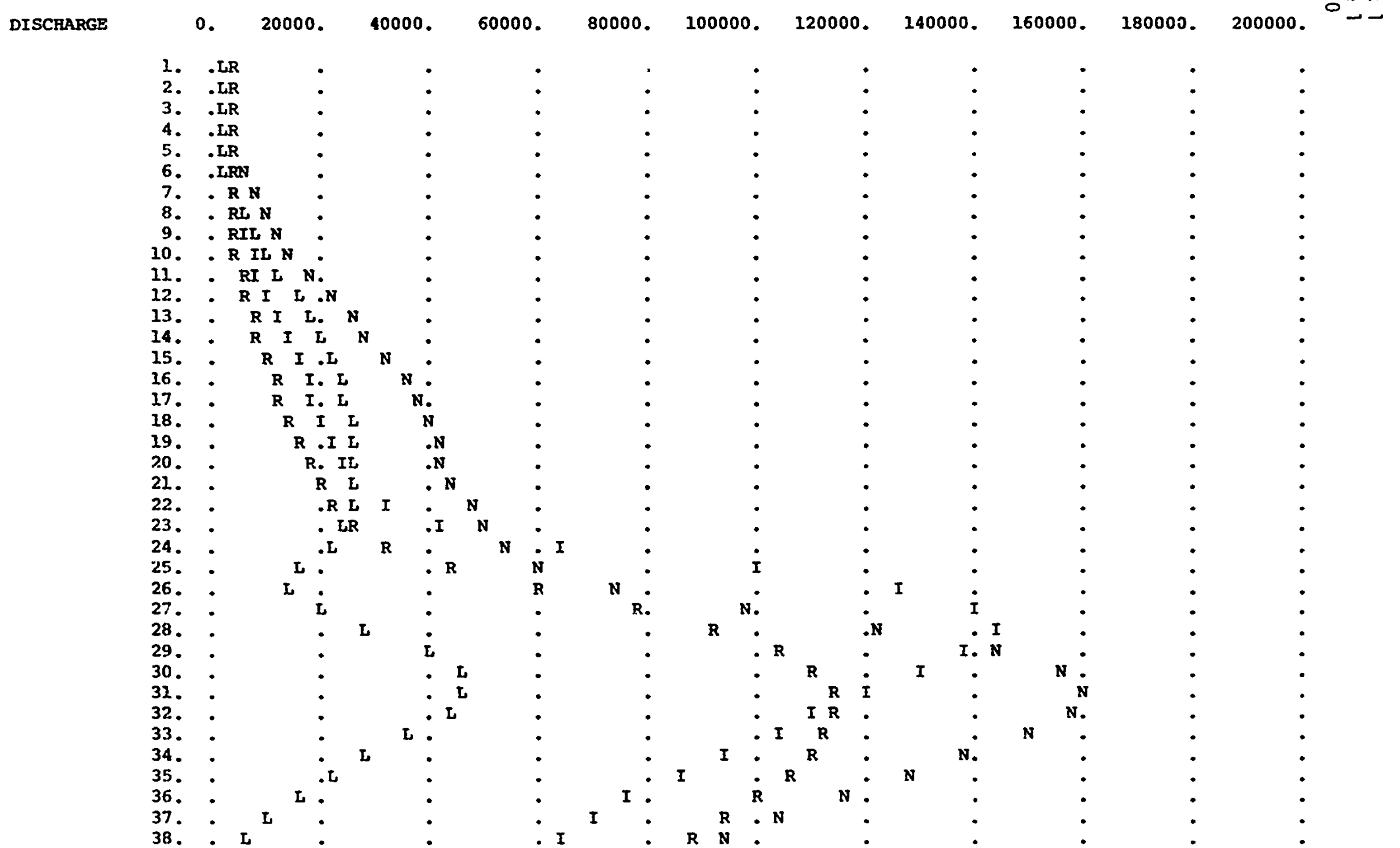
DISCHARGE CFS	STORAGE ACRE-FEET	INCREMENTAL K HOURS	TOTAL K HOURS
0.	0.		
20000.00	18109.60	11.0	11.0
40000.00	36008.59	10.8	10.9
60000.00	54093.49	10.9	10.9
80000.00	72738.12	11.3	11.0
100000.00	92058.15	11.7	11.1
120000.00	111911.10	12.0	11.3
140000.00	131896.37	12.1	11.4
160000.00	151355.19	11.8	11.4

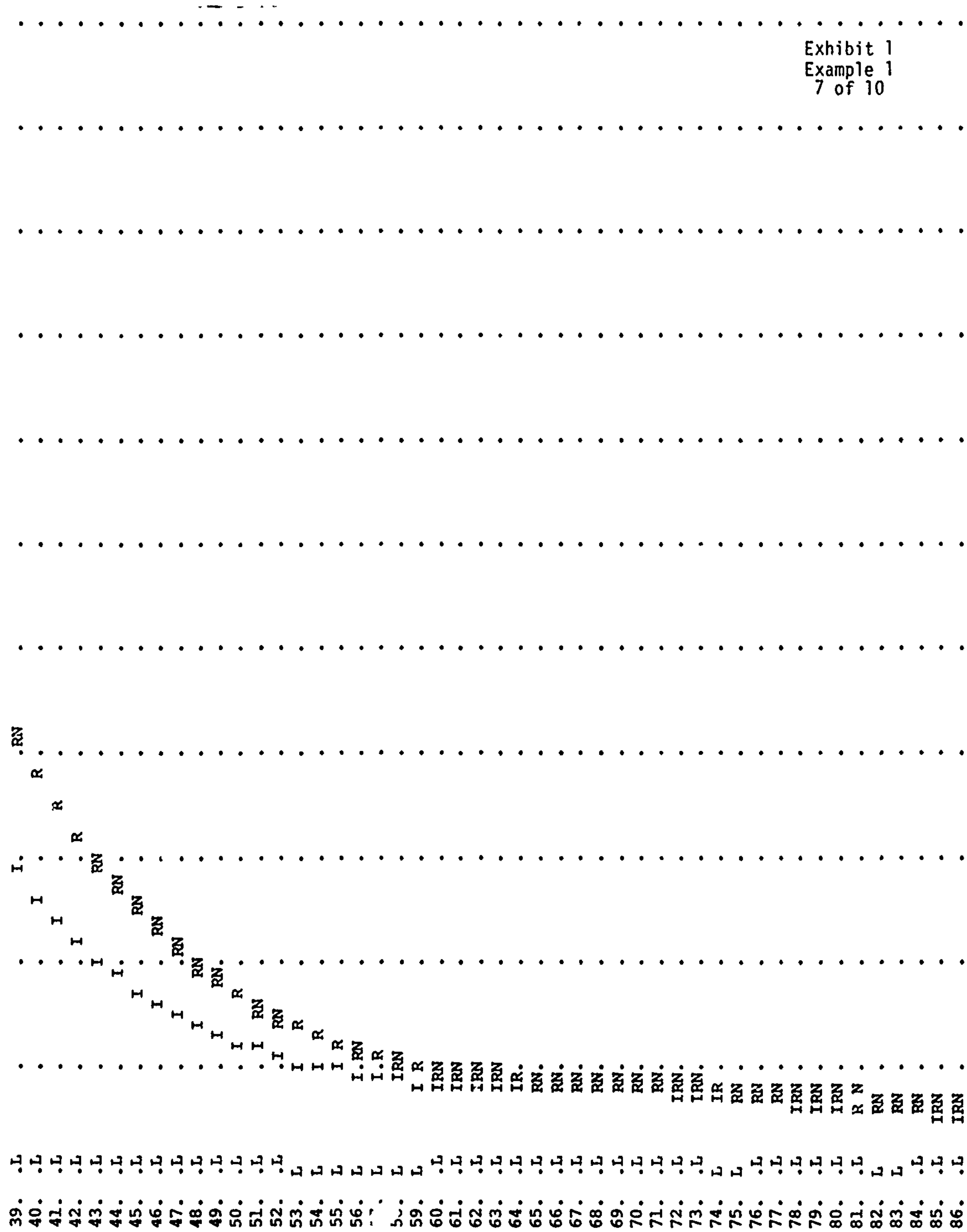
```
OPTIMUM NUMBER OF SUBREACHES=  1

UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

M=      2                3160.   3093.   3025.   2940.   3020.   3207.   3800.
                         4660.   5650.   7203.   8395.   9653.  11400.  13300.
                        15200.  17075.  18600.  20150.  21700.  23575.  25800.
                        31250.  42800.  64650.  99900. 126000. 140000. 143000.
                       138000. 130500. 120500. 110500. 103000.  94300.  85500.
                        76950.  69000.  63100.  57200.  52350.  47500.  43950.
                        40400.  37300.  34200.  31750.  29300.  27550.  25800.
                        24450.  23100.  22000.  20900.  19950.  19000.  18300.
                        17600.  17150.  16700.  16500.  16300.  16225.  16150.
                        16075.  16000.  15900.  15800.  15650.  15500.  15300.
                        15100.  14800.  14500.  14125.  13750.  13375.  13000.
                        12725.  12450.  12175.  11900.  11600.  11300.  11000.
                        10750.  10500.  10250.  10000.   9750.   9500.   9250.
                         9000.   8750.   8500.   8250.   8000.   7750.   7500.
                         7250.   7000.
SUM=  2989206.

ROUTED Q FROM MX=   2 TO    3
RTMD=      1.30 RTCOF=      0.   K=      0.

              COEF=   .01568    .08104    .18079    .23410    .20469    .13678    .07689    .03800    .01666    .00651
                      .00231    .00075

M=      3                3160.   3152.   3130.   3094.   3067.   3078.   3180.
                         3433.   3848.   4469.   5271.   6175.   7223.   8458.
                         9853.  11366.  12925.  14478.  16031.  17622.  19324.
                        21556.  25320.  32232.  44369.  60882.  77811.  92366.
                       103236. 110122. 113537. 113973. 112369. 109323. 105010.
                        99722.  93638.  87363.  81173.  75013.  69124.  63631.
                        58556.  53805.  49451.  45478.  41872.  38617.  35711.
                        33135.  30858.  28836.  27039.  25430.  23981.  22683.
                        21532.  20520.  19649.  18915.  18309.  17816.  17424.
                        17108.  16850.  16633.  16445.  16271.  16104.  15934.
                        15757.  15563.  15343.  15095.  14816.  14514.  14195.
                        13874.  13564.  13263.  12968.  12674.  12379.  12083.
                        11792.  11511.  11238.  10970.  10706.  10446.  10188.
                         9932.   9677.   9424.   9171.   8919.   8668.   8417.
                         8166.   7915.
SUM=  2972298.
```

PLOTTED POINTS(BY PRIORITY)-R=INFLOW AT MX ROUTED TO MY, N=OBS OR NAT AT MY, L=LOCAL (INC) AT MY, I=INFLOW AT MX

UPSTREAM(MX)= 2 DOWNSTREAM(MY)= 3

CHILLICOTHE TO HIGBY - JAN 1959





87. .L IRN
88. .L R N
89. .L R N
90. L RN
91. .L RN
92. .L RN
93. .L IRN
94. .L IRN
95. .L IRN
96. .L R N
97. .L R N
98. L R
99. L R
100. L R

INC LOCAL FLOWS COMPUTED

COMPUTED LOCAL FLOW

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

SUM= 2989206. -SUM= 0. -MAX= 0.

```
COMPUTED LOCAL FLOW

M=      3                1420.   1297.   1187.   1183.   1353.   2772.   4455.
                         6162.   7952.  10031.  12479.  15275.  17977.  19667.
                        21697.  23634.  24975.  25102.  25419.  25353.  25376.
                        25494.  24080.  21068.  15031.  13968.  19539.  28634.
                        39764.  46378.  46463.  43027.  36631.  28677.  21990.
                        15278.   9362.   5837.   2227.   1837.   1176.   1319.
                         1044.   1745.   2049.   2272.   2128.   2133.   1789.
                         1815.   1542.   1014.    261.    570.    719.    717.
                          568.    780.    851.   1085.   1191.   1384.   1601.
                         1804.   1950.   1667.   1855.   2029.   2196.   2366.
                         2543.   2737.   2957.    605.    884.   1186.   1505.
                         1826.   2136.   2437.   2732.    426.    721.   1017.
                         1308.   1589.   1862.   2130.   2394.    754.   1012.
                         1268.   1523.   1776.   2029.   2281.   2532.    183.
                          434.    685.

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=      3                1420.   1297.   1187.   1183.   1353.   2772.   4455.
                         6162.   7952.  10031.  12479.  15275.  17977.  19667.
                        21697.  23634.  24975.  25102.  25419.  25353.  25376.
                        25494.  24080.  21068.  15031.  13968.  19539.  28634.
                        39764.  46378.  46463.  43027.  36631.  28677.  21990.
                        15278.   9362.   5837.   2227.   1837.   1176.   1319.
                         1044.   1745.   2049.   2272.   2128.   2133.   1789.
                         1815.   1542.   1014.    261.    570.    719.    717.
                          568.    780.    851.   1085.   1191.   1384.   1601.
                         1804.   1950.   1667.   1855.   2029.   2196.   2366.
                         2543.   2737.   2957.    605.    884.   1186.   1505.
                         1826.   2136.   2437.   2732.    426.    721.   1017.
                         1308.   1589.   1862.   2130.   2394.    754.   1012.
                         1268.   1523.   1776.   2029.   2281.   2532.    183.
                          434.    685.
SUM=    811142. -SUM=         0. -MAX=         0.
```

EXAMPLE 2 INPUT

```
T1EXAMPLE 2 MODIFIED PULS ROUTING OPTIMIZATION
T2    SCIOTO RIVER  CHILLICOTHE TO HIGBY OHIO
T3    THREE EVENTS - MAR 1964, FEB 1959, JAN 1959
J1    100       3       0       0       1       0       3       0       1       1
ID CHILLICOTHE TO HIGBY - 3 EVENTS
RT      2       3      .5       0       0       0       6       3       3       0
IN      2    MAR64
QO    333     330     400     500     500     550     750    1250    2250    4000
QO   6500    9000   11500   13000   14000   14500   15000   15500   15750   16000
QO  16500   16750   17000   17000   17000   17000   17000   16800   17000   17000
QO  17000   17000   16700   16250   15500   15000   14000   13250   12000   11200
QO  10500   10200   10500   11700   14200   17000   19500   21500   23700   26500
QO  30000   34000   40000   45500   50000   53000   55200   58300   61500   65000
QO  68500   70750   71600   71500   70600   69000   66000   62500   59000   55500
QO  51750   48000   45200   42000   39500   37000   33750   30750   28500   26000
QO  22600   22100   23000   22500   21500   20750   20000   19500   19000   18750
QO  18500   18000   17500   17000   16500   16250   16000   16000   16000   16000
IN      3    MAR64
QO    628     633     637     993    1350    3787    6225    8663   11100   15350
QO  19600   22450   25300   27600   29900   31150   32400   31700   31000   30300
QO  29600   28900   28200   27500   26800   26300   25800   25300   24800   24275
QO  23750   23225   22700   21850   21000   20150   19300   18375   17450   16252
QO  15600   15650   15700   22000   28300   35250   42200   47450   52700   59100
QO  65500   72350   79200   91600  104000  115000  126000  125000  125000  124500
QO124000  121000  118000  115000  112000  109500  107000  102850   98700   93375
QO  88050   82725   77400   72575   67750   62925   58100   54575   51050   47525
QO  44000   41775   39550   37325   35100   34200   33300   32400   31500   31000
QO  30500   30000   29500   28625   27750   26875   26000   25425   24850   24275
IN      2    FEB59
QO   3310    3310    3310    3310    3310    3310    3310    3310    3310    3360
QO   3480    4580    5680    7670    9660   11630   13600   14600   15600   16750
QO  17900   19675   21450   23225   25000   28400   31800   35200   38600   40700
QO  42800   43100   42600   40575   38550   36525   34500   32300   30100   28350
QO  26600   25350   24100   23200   22300   22125   21950   21775   21600   21500
QO  21400   21300   21200   21175   21150   21125   21100   21300   21500   21700
QO  21900   22000   22100   22000   21900   21650   21400   20850   20300   19600
QO  18900   18200   17500   17013   16525   16037   15550   15063   14575   14087
QO  13600   13275   12950   12625   12300   11850   11400   10620    9840    8860
QO   7880    7215    6550    6283    6015    5747    5500    5300    5100    4900
IN      3    FEB59
QO   5210    5210    5210    5210    5210    5210    5210    5210    5210    5480
QO   5890    6300    8050   13175   17300   20700   24100   25450   26800   26600
QO  26400   26200   26000   27000   28000   29700   31400   33850   36300   38150
QO  40000   41850   43700   43850   44000   43400   42800   41500   40200   38450
QO  36700   34900   33100   31650   30200   29550   28900   30100   31300   32200
QO  33100   32250   31400   30550   29700   28850   28000   27650   27300   27250
QO  27200   27150   27100   26950   26800   25000   25000   25000   25000   25000
QO  25000   25000   25000   23937   22875   21813   20750   19687   18625   17563
QO  16500   15875   15250   14625   14000   13375   12750   12125   11500   11063
QO  10625   10187    9750    9313    8875    8437    8000    7600    7200    6800
```

IN 2	JAN59								
QO 3160	3093	3025	2940	3020	3207	3800	4660	5650	7203
QO 8395	9653	11400	13300	15200	17075	18600	20150	21700	23575
QO 25800	31250	42800	64650	99900	126000	140000	143000	138000	130500
QO120500	110500	103000	94300	85500	76950	69000	63100	57200	52350
QO 47500	43950	40400	37300	34200	31750	29300	27550	25800	24450
QO 23100	22000	20900	19950	19000	18300	17600	17150	16700	16500
QO 16300	16225	16150	16075	16000	15900	15800	15650	15500	15300
QO 15100	14800	14500	14125	13750	13375	13000	12725	12450	12175
QO 11900	11600	11300	11000	10750	10500	10250	10000	9750	9500
QO 9250	9000	8750	8500	8250	8000	7750	7500	7250	7000
IN 3	JAN59								
QO 4580	4449	4317	4277	4420	5850	7635	9595	11800	14500
QO 17750	21450	25200	28125	31550	35000	37900	39580	41450	42975
QO 44700	47050	49400	53300	59400	74850	97350	121000	143000	156500
QO160000	157000	149000	138000	127000	115000	103000	93200	83400	76850
QO 70300	64950	59600	55550	51500	47750	44000	40750	37500	34950
QO 32400	29850	27300	26000	24700	23400	22100	21300	20500	20000
QO 19500	19200	19025	18912	18800	18300	18300	18300	18300	18300
QO 18300	18300	18300	15700	15700	15700	15700	15700	15700	15700
QO 15700	13100	13100	13100	13100	13100	13100	13100	13100	11200
QO 11200	11200	11200	11200	11200	11200	11200	8600	8600	8600

EXAMPLE 2 OUTPUT

```
ROUTING OPTIMIZATION INPUT DATA

T1EXAMPLE 2 MODIFIED PULS ROUTING OPTIMIZATION
T2   SCIOTO RIVER  CHILLICOTHE TO HIGBY OHIO
T3   THREE EVENTS - MAR 1964, FEB 1959, JAN 1959

        NPER      IPER     INPUT     IPRNT     IPLOT    IPUNCH    NFLOOD    NPTSQ     ICURV     IFLOW
J1       100         3         0         0         1         0         3        0         1         1

ID CHILLICOTHE TO HIGBY - 3 EVENTS

        RTFR      RTTO      RTMD     RTCOF     XMUSK       LAG       WT1       WT2       WT3    METRIC
RT      2.00      3.00       .50        0.        0.        0.      6.00      3.00      3.00        0.
IN         2     MAR64
     333.00    330.00    400.00    500.00    500.00    550.00    750.00   1250.00   2250.00   4000.00
    6500.00   9000.00  11500.00  13000.00  14000.00  14500.00  15000.00  15500.00  15750.00  16000.00
   16500.00  16750.00  17000.00  17000.00  17000.00  17000.00  17000.00  16800.00  17000.00  17000.00
   17000.00  17000.00  16700.00  16250.00  15500.00  15000.00  14000.00  13250.00  12000.00  11200.00
   10500.00  10200.00  10500.00  11700.00  14200.00  17000.00  19500.00  21500.00  23700.00  26500.00
   30000.00  34000.00  40000.00  45500.00  50000.00  53000.00  55200.00  58300.00  61500.00  65000.00
   68500.00  70750.00  71600.00  71500.00  70600.00  69000.00  66000.00  62500.00  59000.00  55500.00
   51750.00  48000.00  45200.00  42000.00  39500.00  37000.00  33750.00  30750.00  28500.00  26000.00
   22600.00  22100.00  23000.00  22500.00  21500.00  20750.00  20000.00  19500.00  19000.00  18750.00
   18500.00  18000.00  17500.00  17000.00  16500.00  16250.00  16000.00  16000.00  16000.00  16000.00
IN         3     MAR64
     628.00    633.00    637.00    993.00   1350.00   3787.00   6225.00   8663.00  11100.00  15350.00
   19600.00  22450.00  25300.00  27600.00  29900.00  31150.00  32400.00  31700.00  31000.00  30300.00
   29600.00  28900.00  28200.00  27500.00  25800.00  26300.00  25800.00  25300.00  24800.00  24275.00
   23750.00  23225.00  22700.00  21850.00  21000.00  20150.00  19300.00  18375.00  17450.00  16252.00
   15600.00  15650.00  15700.00  22000.00  28300.00  35250.00  42200.00  47450.00  52700.00  59100.00
   65500.00  72350.00  79200.00  91600.00 104000.00 115000.00 126000.00 125000.00 125000.00 124500.00
  124000.00 121000.00 118000.00 115000.00 112000.00 109500.00 107000.00 102850.00  98700.00  93375.00
   88050.00  82725.00  77400.00  72575.00  67750.00  62925.00  58100.00  54575.00  51050.00  47525.00
   44000.00  41775.00  39550.00  37325.00  35100.00  34200.00  33300.00  32400.00  31500.00  31000.00
   30500.00  30000.00  29500.00  28625.00  27750.00  26875.00  26000.00  25425.00  24850.00  24275.00
IN         2     FEB59
    3310.00   3310.00   3310.00   3310.00   3310.00   3310.00   3310.00   3310.00   3310.00   3360.00
    3480.00   4580.00   5680.00   7670.00   9660.00  11630.00  13600.00  14600.00  15600.00  16750.00
   17900.00  19675.00  21450.00  23225.00  25000.00  28400.00  31800.00  35200.00  38600.00  40700.00
   42800.00  43100.00  42600.00  40575.00  38550.00  36525.00  34500.00  32300.00  30100.00  28350.00
   26600.00  25350.00  24100.00  23200.00  22300.00  22125.00  21950.00  21775.00  21600.00  21500.00
   21400.00  21300.00  21200.00  21175.00  21150.00  21125.00  21100.00  21300.00  21500.00  21700.00
   21900.00  22000.00  22100.00  22000.00  21900.00  21650.00  21400.00  20850.00  20300.00  19600.00
   18900.00  18200.00  17500.00  17013.00  16525.00  16037.00  15550.00  15063.00  14575.00  14087.00
   13600.00  13275.00  12950.00  12625.00  12300.00  11850.00  11400.00  10620.00   9840.00   8860.00
    7880.00   7215.00   6550.00   6283.00   6015.00   5747.00   5500.00   5300.00   5100.00   4900.00
```

IN	3	FEB59							
5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5480.00
5890.00	6300.00	8050.00	13175.00	17300.00	20700.00	24100.00	25450.00	26800.00	26600.00
26400.00	26200.00	26000.00	27000.00	28000.00	29700.00	31400.00	33850.00	36300.00	38150.00
40000.00	41850.00	43700.00	43850.00	44000.00	43400.00	42800.00	41500.00	40200.00	38450.00
36700.00	34900.00	33100.00	31650.00	30200.00	29550.00	28900.00	30100.00	31300.00	32200.00
33100.00	32250.00	31400.00	30550.00	29700.00	28850.00	28000.00	27650.00	27300.00	27250.00
27200.00	27150.00	27100.00	26950.00	26800.00	25000.00	25000.00	25000.00	25000.00	25000.00
25000.00	25000.00	25000.00	23937.00	22875.00	21813.00	20750.00	19687.00	18625.00	17563.00
16500.00	15875.00	15250.00	14625.00	14000.00	13375.00	12750.00	12125.00	11500.00	11063.00
10625.00	10187.00	9750.00	9313.00	8875.00	8437.00	8000.00	7600.00	7200.00	6800.00
IN	2	JAN59							
3160.00	3093.00	3025.00	2940.00	3020.00	3207.00	3800.00	4660.00	5650.00	7203.00
8395.00	9653.00	11400.00	13300.00	15200.00	17075.00	18600.00	20150.00	21700.00	23575.00
25800.00	31250.00	42800.00	64650.00	99900.00	126000.00	140000.00	143000.00	138000.00	130500.00
120500.00	110500.00	103000.00	94300.00	85500.00	76950.00	69000.00	63100.00	57200.00	52350.00
47500.00	43950.00	40400.00	37300.00	34200.00	31750.00	29300.00	27550.00	25800.00	24450.00
23100.00	22000.00	20900.00	19950.00	19000.00	18300.00	17600.00	17150.00	16700.00	16500.00
16300.00	16225.00	16150.00	16075.00	16000.00	15900.00	15800.00	15650.00	15500.00	15300.00
15100.00	14800.00	14500.00	14125.00	13750.00	13375.00	13000.00	12725.00	12450.00	12175.00
11900.00	11600.00	11300.00	11000.00	10750.00	10500.00	10250.00	10000.00	9750.00	9500.00
9250.00	9000.00	8750.00	8500.00	8250.00	8000.00	7750.00	7500.00	7250.00	7000.00
IN	3	JAN59							
4580.00	4449.00	4317.00	4277.00	4420.00	5850.00	7635.00	9595.00	11800.00	14500.00
17750.00	21450.00	25200.00	28125.00	31550.00	35000.00	37900.00	39580.00	41450.00	42975.00
44700.00	47050.00	49400.00	53300.00	59400.00	74850.00	97350.00	121000.00	143000.00	156500.00
160000.00	157000.00	149000.00	138000.00	127000.00	115000.00	103000.00	93200.00	83400.00	76850.00
70300.00	64950.00	59600.00	55550.00	51500.00	47750.00	44000.00	40750.00	37500.00	34950.00
32400.00	29850.00	27300.00	26000.00	24700.00	23400.00	22100.00	21300.00	20500.00	20000.00
19500.00	19200.00	19025.00	18912.00	18800.00	18300.00	18300.00	18300.00	18300.00	18300.00
18300.00	18300.00	18300.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00
15700.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	11200.00
11200.00	11200.00	11200.00	11200.00	11200.00	11200.00	11200.00	8600.00	8600.00	8600.00

OPTIMIZATION ROUTINE OUTPUT

	COMPUTED ERRORS:		
NEG LOCAL	TOO EARLY	TOO LATE	TOTAL
-849365.76	-2581486.47	-68628.41	-3499480.64
-819234.68	-2560121.77	-67789.14	-3447145.59
-785458.14	-2535955.15	-66665.14	-3388078.43
-747741.89	-2508603.79	-65160.20	-3321505.87
-705765.27	-2393761.49	-63159.94	-3162686.70
-664018.08	-2359242.63	0.	-3023260.72
-616885.35	-2346971.39	0.	-2963856.74
-565217.43	-2317523.56	0.	-2882740.99
-508312.16	-2200841.55	0.	-2709153.70
-445702.86	-2139503.66	0.	-2585206.52
-377791.89	-2083016.71	0.	-2460808.60
-306797.41	-2012914.76	0.	-2319712.16
-233715.53	-1804532.21	0.	-2038247.74
-158094.69	-1720292.54	0.	-1878387.23
-89628.87	-1654002.78	0.	-1743631.65
-43081.67	-1506250.57	0.	-1549332.24
-7489.41	-1395902.47	0.	-1403391.88
0.	-1183336.68	0.	-1183336.68
0.	-1090235.01	0.	-1090235.01
0.	-990696.19	0.	-990696.19
0.	-859390.85	0.	-859390.85
-21646.69	-807705.07	-10823.34	-840175.10
-165576.24	-713573.95	-82788.12	-961938.32
-1361447.82	-299571.38	-680723.91	-2341743.12
-165576.24	-713573.95	-82788.12	-961938.32
0.	-859390.85	0.	-859390.85
-21646.69	-807705.07	-10823.34	-840175.10
-106354.09	-795282.12	-53177.05	-954813.26
-1804058.03	-303778.83	-902029.02	-3009865.88
-265306.06	-705002.08	-132653.03	-1102961.17
-11272.05	-875774.75	-5636.03	-892682.83
0.	-970422.21	0.	-970422.21
-1439137.27	-354030.03	-719568.63	-2512735.93
-106354.09	-795282.12	-53177.05	-954813.26
0.	-970422.21	0.	-970422.21
-21797.45	-804259.29	-10898.73	-836955.48
-4656.47	-755483.82	-2328.24	-762468.53
-18689.12	-704936.14	-9344.56	-732969.82
-92123.34	-704936.14	-46061.67	-843121.15
-5769.89	-719040.88	-2884.94	-727695.72
-6457.65	-711320.12	-3228.82	-721006.60
-15443.06	-763747.29	-7721.53	-786911.88

-42351.17	-718193.01	-21175.59	-781719.77
-62941.55	-675589.33	-31470.78	-770001.66
-29704.89	-766115.68	-14852.45	-810673.02
-32988.86	-722275.17	-16494.43	-771758.47
-3499.33	-756551.31	-1749.67	-761800.31
-40772.56	-704936.14	-20386.28	-766094.98
-4833.06	-729980.56	-2416.53	-737230.14
-8378.95	-729129.11	-4189.47	-741697.53
-11274.88	-711987.76	-5637.44	-728900.08
-17504.97	-715245.47	-8752.49	-741502.93
-7683.38	-727885.32	-3841.69	-739410.38
-12515.39	-717419.30	-6257.69	-736192.38
-5163.13	-748233.11	-2581.56	-755977.81
-8411.34	-704936.14	-4205.67	-717553.16
-8688.69	-724755.31	-4344.34	-737788.34
-10249.36	-703814.24	-5124.68	-719188.28
-11456.35	-720193.71	-5728.17	-737378.23
-8755.88	-710257.95	-4377.94	-723391.76
-12135.24	-704049.89	-6067.62	-722252.75
-6781.60	-705836.91	-3390.80	-716009.31
-7499.38	-705836.91	-3749.69	-717085.99
-6469.06	-705836.91	-3234.53	-715540.50
-153732.84	-718542.37	-76866.42	-949141.63
-154771.06	-718584.02	-77385.53	-950740.61
-181114.45	-701108.55	-90557.23	-972780.23
-161801.65	-664337.35	-80900.82	-907039.82
-217651.59	-771655.81	-108825.79	-1098133.20
-183321.33	-678850.20	-91660.66	-953832.19
-204414.20	-768187.37	-102207.10	-1074808.67
-340020.23	-718542.37	-170010.11	-1228572.71
-76594.71	-721828.48	-38297.35	-836720.54
-153308.16	-717867.30	-76654.08	-947829.54
-156096.26	-719919.43	-78048.13	-954063.82
-135436.39	-702364.76	-67718.19	-905519.34
-173056.85	-734623.49	-86528.42	-994208.76
-150598.35	-714275.36	-75299.17	-940172.88
-159598.66	-757470.92	-79799.33	-996868.92
-209567.90	-718542.37	-104783.95	-1032894.22
-99465.11	-718542.37	-49732.55	-867740.03
-153275.20	-718241.59	-76637.60	-948154.38
-154164.21	-718943.19	-77082.11	-950189.51
-147248.77	-713218.62	-73624.38	-934091.77
-160090.85	-723855.6[illegible]	-80045.42	-963991.89
-152794.70	-717159.46	-76397.35	-946351.50
-153996.88	-719892.56	-76998.44	-950887.88
-171246.45	-718542.37	-85623.23	-975412.05
-136730.16	-718542.37	-68365.08	-923637.60
-6469.06	-705836.91	-3234.53	-715540.50

STORAGE-OUTFLOW FUNCTION, UNSMOOTHED

SUM OF COMPUTED ERRORS = -715540.5

ADOPTED STORAGE-OUTFLOW TABLE   TRAVEL TIME INDICATOR(K=STORAGE/DISCHARGE*0.08264)

DISCHARGE CFS	STORAGE ACRE-FEET	INCREMENTAL K HOURS	TOTAL K HOURS
0.	0.		
20000.00	14548.87	8.8	8.8
40000.00	33657.01	11.6	10.2
60000.00	54972.57	12.9	11.1
80000.00	77082.73	13.4	11.7
100000.00	85120.27	4.9	10.3
120000.00	129715.68	27.0	13.1
140000.00	156314.08	16.1	13.5
160000.00	183725.04	16.6	13.9

STORAGE-OUTFLOW FUNCTION, SMOOTHED

COMPUTED ERRORS:

NEG LOCAL	TOO EARLY	TOO LATE	TOTAL
-68477.12	-832049.77	-34238.56	-934765.45

SMOOTHED BY 4TH ORDER POLYNOMIAL AS FOLLOWS:

```
S =  -.1265E+04 Q**0
      .1061E+01 Q**1
     -.8053E-05 Q**2
      .1023E-09 Q**3
     -.3000E-15 Q**4
```

ADOPTED STORAGE-OUTFLOW TABLE   TRAVEL TIME INDICATOR(K=STORAGE/DISCHARGE*0.08264)

DISCHARGE CFS	STORAGE ACRE-FEET	INCREMENTAL K HOURS	TOTAL K HOURS
0.	0.		
20000.00	17512.36	10.6	10.6
40000.00	34085.11	10.0	10.3
60000.00	51634.78	10.6	10.4
80000.00	72190.99	12.4	10.9
100000.00	96631.31	14.8	11.7
120000.00	124681.23	17.0	12.6
140000.00	154914.17	18.3	13.4
160000.00	184751.47	18.1	14.0

```
OPTIMUM NUMBER OF SUBREACHES=  1

UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

M=     2              333.    330.    400.    500.    500.    550.    750.
                     1250.   2250.   4000.   6500.   9000.  11500.  13000.
                    14000.  14500.  15000.  15500.  15750.  16000.  16500.
                    16750.  17000.  17000.  17000.  17000.  17000.  16800.
                    17000.  17000.  17000.  17000.  16700.  16250.  15500.
                    15000.  14000.  13250.  12000.  11200.  10500.  10200.
                    10500.  11700.  14200.  17000.  19500.  21500.  23700.
                    26500.  30000.  34000.  40000.  45500.  50000.  53000.
                    55200.  58300.  61500.  65000.  68500.  70750.  71600.
                    71500.  70600.  69000.  66000.  62500.  59000.  55500.
                    51750.  48000.  45200.  42000.  39500.  37000.  33750.
                    30750.  28500.  26000.  22600.  22100.  23000.  22500.
                    21500.  20750.  20000.  19500.  19000.  18750.  18500.
                    18000.  17500.  17000.  16500.  16250.  16000.  16000.
                    16000.  16000.
SUM=  2541213.

ROUTED Q FROM MX=   2 TO    3
RTMD=      1.30 RTCOF=      0.    K=      0.

             COEF=   .01709    .08728    .19134    .24157    .20394    .13048    .06995    .03292    .01374    .00510
                     .00172    .00053

M=     3              333.    333.    341.    368.    401.    431.    486.
                      613.    895.   1448.   2391.   3720.   5340.   7054.
                     8653.  10041.  11209.  12211.  13058.  13757.  14375.
                    14933.  15415.  15808.  16104.  16326.  16493.  16594.
                    16670.  16752.  16813.  16860.  16857.  16762.  16542.
                    16222.  15795.  15257.  14604.  13859.  13112.  12427.
                    11912.  11711.  12018.  12906.  14232.  15787.  17477.
                    19367.  21648.  24342.  27637.  31570.  35781.  39872.
                    43401.  46706.  49972.  53260.  56600.  59824.  62291.
                    64284.  65740.  66614.  66805.  66255.  65070.  63387.
                    61285.  58653.  55669.  52681.  49727.  46886.  44036.
                    41118.  38184.  35338.  32465.  29833.  27937.  26587.
                    25393.  24282.  23265.  22350.  21543.  20849.  20270.
                    19756.  19259.  18760.  18262.  17794.  17380.  17038.
                    16780.  16587.
SUM=  2484104.
```

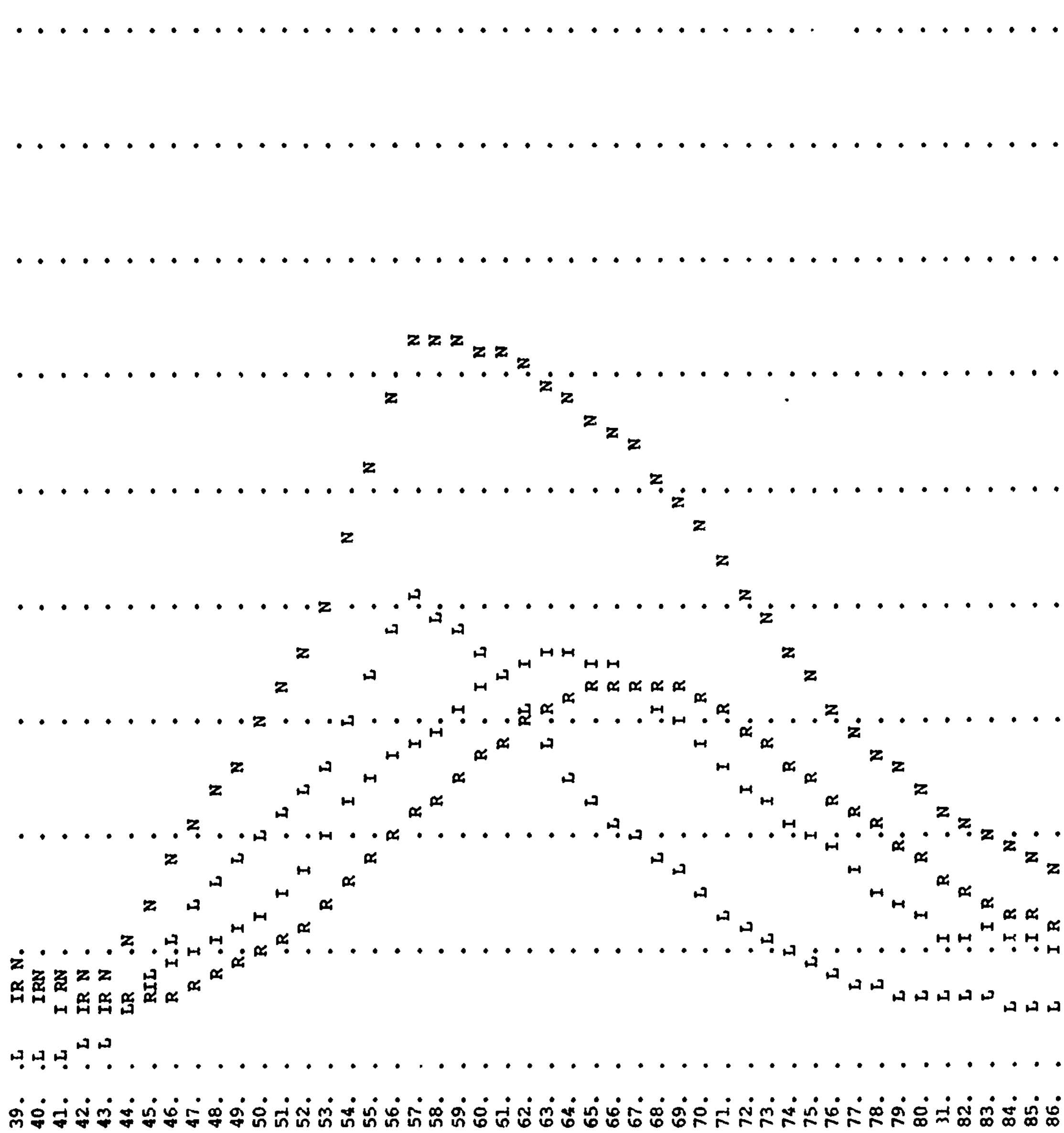
PLOTTED POINTS(BY PRIORITY)-R=INFLOW AT MX ROUTED TO MY, N=OBS OR NAT AT MY, L=LOCAL (INC) AT MY, I=INFLOW AT MX

UPSTREAM(MX)= 2 DOWNSTREAM(MY)= 3

CHILLICOTHE TO HIGBY - 3 EVENTS

```
DISCHARGE
     0.    20000.    40000.    60000.    80000.   100000.   120000.   140000.   160000.   180000.   200000.
  1.  R         .         .         .         .         .         .         .         .         .         .         .
  2.  R         .         .         .         .         .         .         .         .         .         .         .
  3.  R         .         .         .         .         .         .         .         .         .         .         .
  4.  R         .         .         .         .         .         .         .         .         .         .         .
  5.  RN        .         .         .         .         .         .         .         .         .         .         .
  6.  R N       .         .         .         .         .         .         .         .         .         .         .
  7.  R  N      .         .         .         .         .         .         .         .         .         .         .
  8.  RI  N     .         .         .         .         .         .         .         .         .         .         .
  9.  RI   LN   .         .         .         .         .         .         .         .         .         .         .
 10.  .RI    LN .         .         .         .         .         .         .         .         .         .         .
 11.  .R I     LN         .         .         .         .         .         .         .         .         .         .
 12.  . R  I   L.N        .         .         .         .         .         .         .         .         .         .
 13.  .  R  I   L  N      .         .         .         .         .         .         .         .         .         .
 14.  .   R  I  L   N     .         .         .         .         .         .         .         .         .         .
 15.  .   R  I  .L   N    .         .         .         .         .         .         .         .         .         .
 16.  .    R I  .L    N   .         .         .         .         .         .         .         .         .         .
 17.  .     R I .L    N   .         .         .         .         .         .         .         .         .         .
 18.  .     R I L     N   .         .         .         .         .         .         .         .         .         .
 19.  .      RIL.     N   .         .         .         .         .         .         .         .         .         .
 20.  .      RL .    N    .         .         .         .         .         .         .         .         .         .
 21.  .      RL .    N    .         .         .         .         .         .         .         .         .         .
 22.  .      RI .   N     .         .         .         .         .         .         .         .         .         .
 23.  .     L RI.   N     .         .         .         .         .         .         .         .         .         .
 24.  .     L RI.   N     .         .         .         .         .         .         .         .         .         .
 25.  .    L  RI.  N      .         .         .         .         .         .         .         .         .         .
 26.  .    L  RI.  N      .         .         .         .         .         .         .         .         .         .
 27.  .    L  RI.  N      .         .         .         .         .         .         .         .         .         .
 28.  .   L   R .  N      .         .         .         .         .         .         .         .         .         .
 29.  .   L   RI. N       .         .         .         .         .         .         .         .         .         .
 30.  .   L   RI. N       .         .         .         .         .         .         .         .         .         .
 31.  .  L    RI. N       .         .         .         .         .         .         .         .         .         .
 32.  .  L    RI. N       .         .         .         .         .         .         .         .         .         .
 33.  .  L    R .N        .         .         .         .         .         .         .         .         .         .
 34.  .  L    R .N        .         .         .         .         .         .         .         .         .         .
 35.  . L     R .N        .         .         .         .         .         .         .         .         .         .
 36.  . L     R N         .         .         .         .         .         .         .         .         .         .
 37.  . L    IR N         .         .         .         .         .         .         .         .         .         .
 38.  . L    IRN.         .         .         .         .         .         .         .         .         .         .
```

Exhibit 1
Example 2
10 of 25



```
 87. .    L    I R    N .         .         .         .         .         .         .         .         .         .
 88. .    L    IR    N  .         .         .         .         .         .         .         .         .         .
 89. .    L    IR    N  .         .         .         .         .         .         .         .         .         .
 90. .    L   IR     N  .         .         .         .         .         .         .         .         .         .
 91. .    L   IR    N   .         .         .         .         .         .         .         .         .         .
 92. .    L   IR    N   .         .         .         .         .         .         .         .         .         .
 93. .    L   IR    N   .         .         .         .         .         .         .         .         .         .
 94. .    L   R.   N    .         .         .         .         .         .         .         .         .         .
 95. .    L  IR.   N    .         .         .         .         .         .         .         .         .         .
 96. .    L  IR.  N     .         .         .         .         .         .         .         .         .         .
 97. .   L   IR.  N     .         .         .         .         .         .         .         .         .         .
 98. .   L   IR.  N     .         .         .         .         .         .         .         .         .         .
 99. .   L   R . N      .         .         .         .         .         .         .         .         .         .
100. .   L   R . N      .         .         .         .         .         .         .         .         .         .
```

```
UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

M=     2              3310.   3310.   3310.   3310.   3310.   3310.   3310.
                      3310.   3310.   3360.   3480.   4580.   5680.   7670.
                      9660.  11630.  13600.  14600.  15600.  16750.  17900.
                     19675.  21450.  23225.  25000.  28400.  31800.  35200.
                     38600.  40700.  42800.  43100.  42600.  40575.  38550.
                     36525.  34500.  32300.  30100.  28350.  26600.  25350.
                     24100.  23200.  22300.  22125.  21950.  21775.  21600.
                     21500.  21400.  21300.  21200.  21175.  21150.  21125.
                     21100.  21300.  21500.  21700.  21900.  22000.  22100.
                     22000.  21900.  21650.  21400.  20850.  20300.  19600.
                     18900.  18200.  17500.  17013.  16525.  16037.  15550.
                     15063.  14575.  14087.  13600.  13275.  12950.  12625.
                     12300.  11850.  11400.  10620.   9840.   8860.   7880.
                      7215.   6550.   6283.   6015.   5747.   5500.   5300.
                      5100.   4900.
SUM=  1786160.

ROUTED Q FROM MX=   2 TO    3
RTMD=      1.30 RTCOF=      0.    K=      0.

          COEF=   .01709    .08728    .19134    .24157    .20394    .13048    .06995    .03292    .01374    .00510
                  .00172    .00053

M=     3              3310.   3310.   3310.   3310.   3310.   3310.   3310.
                      3310.   3310.   3316.   3342.   3513.   3914.   4599.
                      5607.   6857.   8285.   9727.  11060.  12329.  13568.
                     14863.  16276.  17780.  19351.  21231.  23540.  26132.
                     28935.  31723.  34333.  36576.  38209.  39088.  39212.
                     38776.  37927.  36748.  35304.  33722.  32096.  30503.
                     28999.  27607.  26343.  25268.  24427.  23760.  23220.
                     22786.  22438.  22155.  21919.  21729.  21581.  21466.
                     21374.  21329.  21347.  21413.  21514.  21627.  21737.
                     21819.  21853.  21833.  21753.  21589.  21325.  20967.
                     20520.  20008.  19472.  18922.  18388.  17866.  17352.
                     16844.  16342.  15843.  15347.  14874.  14437.  14028.
                     13639.  13251.  12848.  12392.  11856.  11234.  10524.
                      9786.   9066.   8408.   7848.   7360.   6929.   6550.
                      6215.   5914.
SUM=  1777471.
```

PLOTTED POINTS(BY PRIORITY)-R=INFLOW AT MX ROUTED TO MY, N=OBS OR NAT AT MY, L=LOCAL (INC) AT MY, I=INFLOW AT MX

UPSTREAM(MX)= 2 DOWNSTREAM(MY)= 3

CHILLICOTHE TO HIGBY - 3 EVENTS

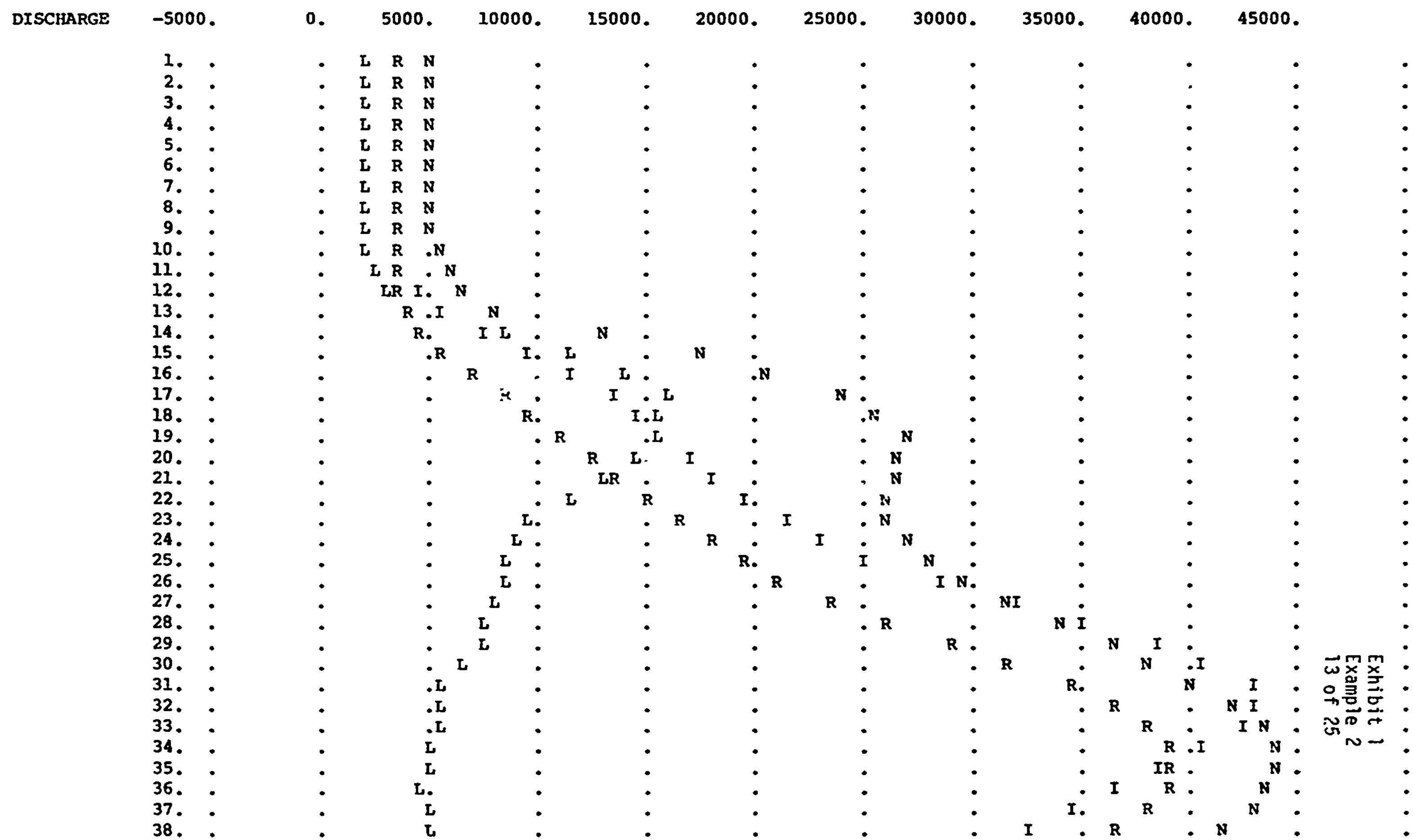
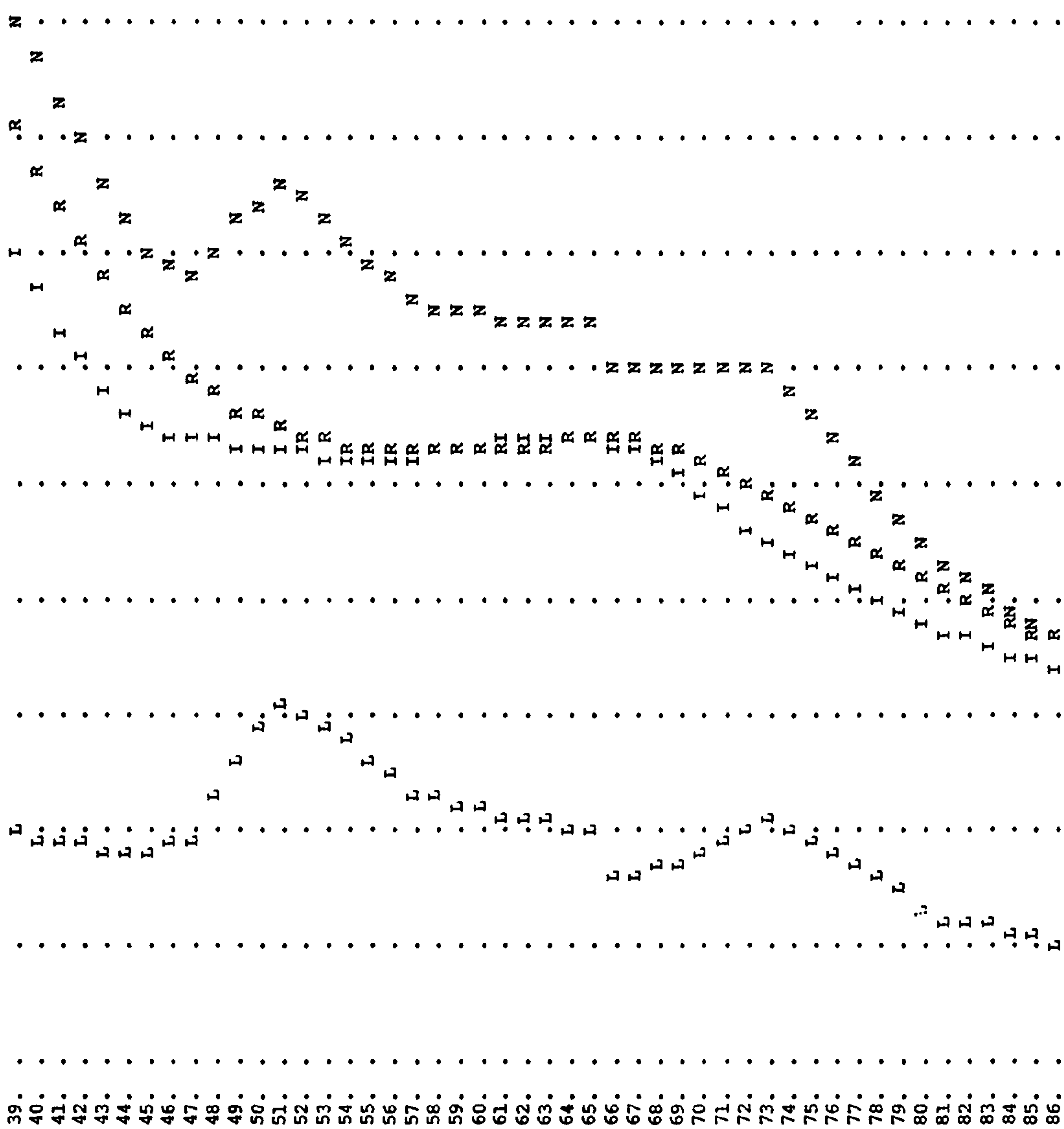


Exhibit 1
Example 2
14 of 25



```
 87. .         L         .         .  I  R   .         .         .         .         .         .         .         .
 88. .        L.         .         .I  NR    .         .         .         .         .         .         .         .
 89. .        L.         .         I   NR    .         .         .         .         .         .         .         .
 90. .         L         .       I . R       .         .         .         .         .         .         .         .
 91. .         L         .     I   .R        .         .         .         .         .         .         .         .
 92. .         .L        .   I     R         .         .         .         .         .         .         .         .
 93. .         .L        .  I    R N         .         .         .         .         .         .         .         .
 94. .         . L       .  I   R N.         .         .         .         .         .         .         .         .
 95. .         . L       . I   R N .         .         .         .         .         .         .         .         .
 96. .         . L       .I   R N  .         .         .         .         .         .         .         .         .
 97. .         . L       .I  R N   .         .         .         .         .         .         .         .         .
 98. .         . L       .I R N    .         .         .         .         .         .         .         .         .
 99. .         . L       I R N     .         .         .         .         .         .         .         .         .
100. .         . L       I R N     .         .         .         .         .         .         .         .         .
```

```
UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

M=     2               3160.   3093.   3025.   2940.   3020.   3207.   3800.
                       4660.   5650.   7203.   8395.   9653.  11400.  13300.
                      15200.  17075.  18600.  20150.  21700.  23575.  25800.
                      31250.  42800.  64650.  99900. 126000. 140000. 143000.
                     138000. 130500. 120500. 110500. 103000.  94300.  85500.
                      76950.  69000.  63100.  57200.  52350.  47500.  43950.
                      40400.  37300.  34200.  31750.  29300.  27550.  25800.
                      24450.  23100.  22000.  20900.  19950.  19000.  18300.
                      17600.  17150.  16700.  16500.  16300.  16225.  16150.
                      16075.  16000.  15900.  15800.  15650.  15500.  15300.
                      15100.  14800.  14500.  14125.  13750.  13375.  13000.
                      12725.  12450.  12175.  11900.  11600.  11300.  11000.
                      10750.  10500.  10250.  10000.   9750.   9500.   9250.
                       9000.   8750.   8500.   8250.   8000.   7750.   7500.
                       7250.   7000.
SUM=  2989206.

ROUTED Q FROM MX=   2 TO    3
RTMD=      1.30 RTCOF=      0.   K=      0.

             COEF=    .01709    .08728    .19134    .24157    .20394    .13048    .06995    .03292    .01374    .00510
                      .00172    .00053

M=     3               3160.   3152.   3129.   3092.   3065.   3077.   3183.
                       3442.   3867.   4502.   5320.   6239.   7302.   8554.
                       9967.  11497.  13070.  14634.  16194.  17792.  19503.
                      21826.  25782.  33055.  45579.  61964.  77255.  89485.
                      98882. 104759. 108128. 109325. 108907. 107241. 104424.
                     100656.  95645.  90194.  84660.  79012.  72751.  66933.
                      61604.  56211.  51145.  46647.  42656.  39088.  35857.
                      33064.  30646.  28539.  26694.  25062.  23608.  22318.
                      21181.  20190.  19371.  18684.  18118.  17657.  17293.
                      17000.  16761.  16560.  16384.  16221.  16060.  15897.
                      15724.  15532.  15313.  15065.  14785.  14482.  14161.
                      13839.  13528.  13227.  12932.  12639.  12344.  12048.
                      11757.  11476.  11203.  10936.  10673.  10413.  10155.
                       9900.   9646.   9392.   9140.   8888.   8637.   8386.
                       8135.   7885.
SUM=  2972963.
```

PLOTTED POINTS(BY PRIORITY)-R=INFLOW AT MX ROUTED TO MY, N=OBS OR NAT AT MY, L=LOCAL (INC) AT MY, I=INFLOW AT MX

UPSTREAM(MX)= 2 DOWNSTREAM(MY)= 3

CHILLICOTHE TO HIGBY - 3 EVENTS

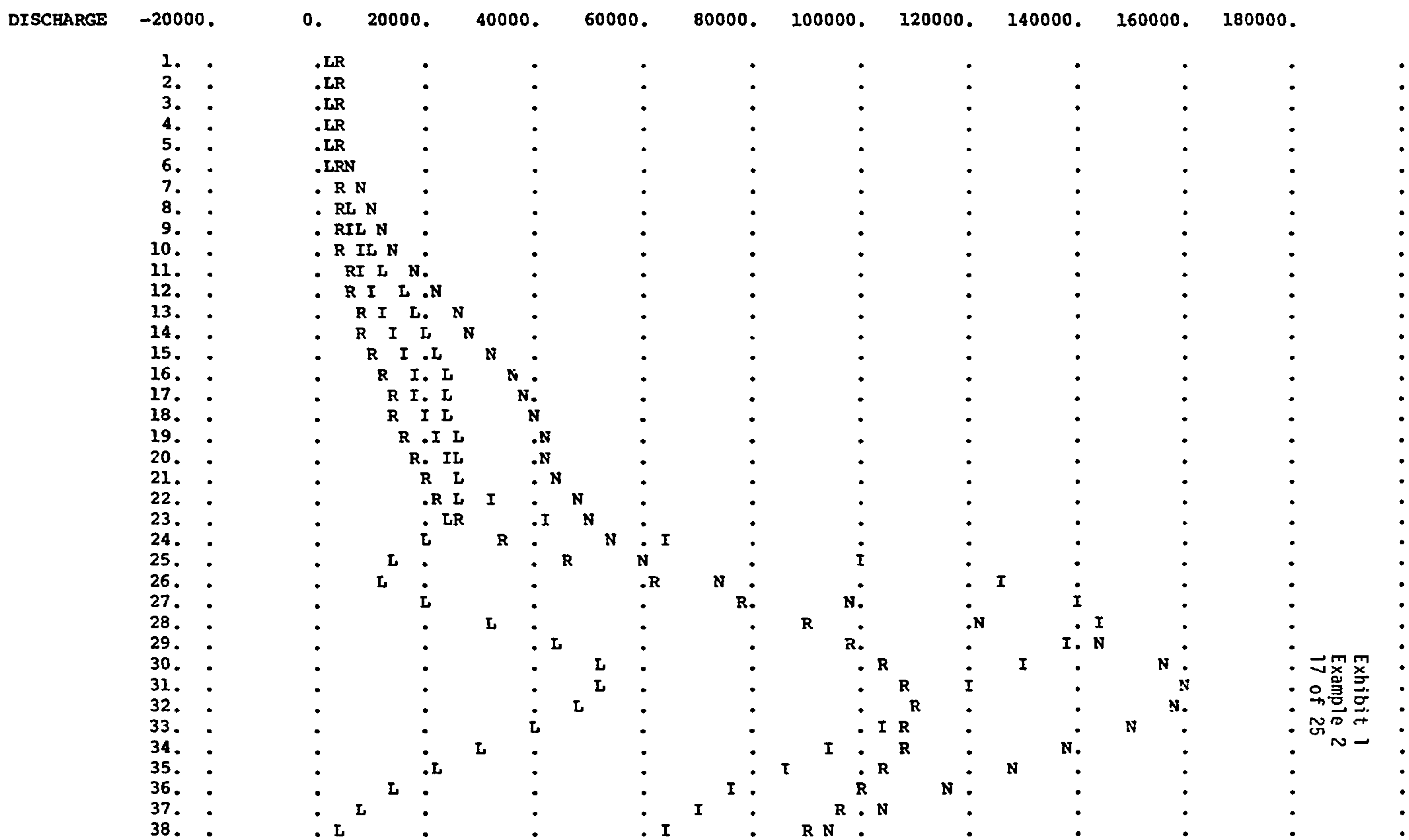
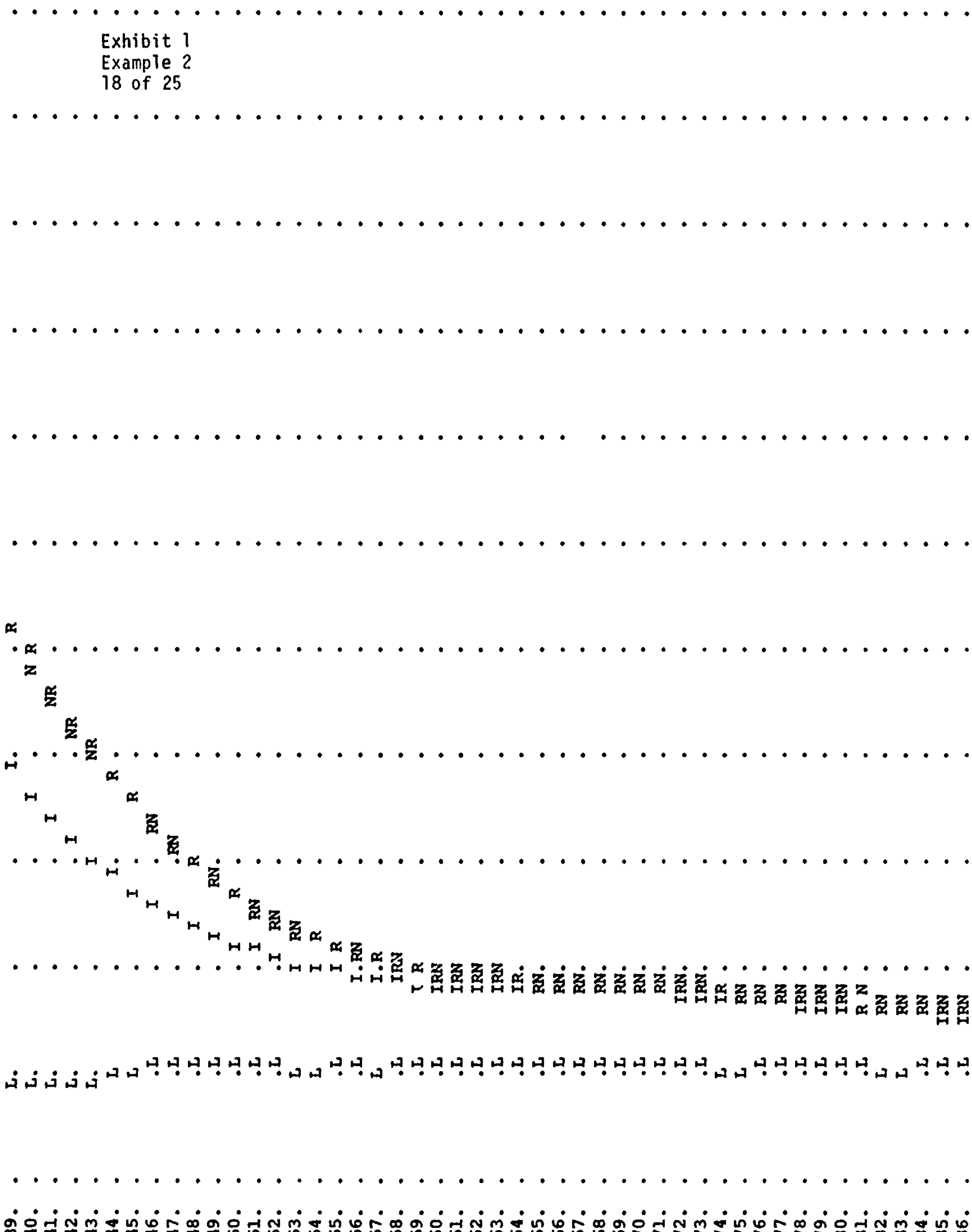


Exhibit 1
Example 2

Exhibit 1
Example 2
18 of 25



87.	.	.L IRN	.	.	.	.	.	.	.	.	.	.
88.	.	.L R N	.	.	.	.	.	.	.	.	.	.
89.	.	.L R N	.	.	.	.	.	.	.	.	.	.
90.	.	L RN	.	.	.	.	.	.	.	.	.	.
91.	.	.L RN	.	.	.	.	.	.	.	.	.	.
92	.	.L RN	.	.	.	.	.	.	.	.	.	.
93.	.	.L IRN	.	.	.	.	.	.	.	.	.	.
94.	.	.L IRN	.	.	.	.	.	.	.	.	.	.
95.	.	.L IRN	.	.	.	.	.	.	.	.	.	.
96.	.	.L R N	.	.	.	.	.	.	.	.	.	.
97.	.	.L R N	.	.	.	.	.	.	.	.	.	.
98.	.	L R	.	.	.	.	.	.	.	.	.	.
99.	.	L R	.	.	.	.	.	.	.	.	.	.
100.	.	L R	.	.	.	.	.	.	.	.	.	.

INC LOCAL FLOWS COMPUTED

COMPUTED LOCAL FLOW

M= 2

333.	330.	400.	500.	500.	550.	750.
1250.	2250.	4000.	6500.	9000.	11500.	13000.
14000.	14500.	15000.	15500.	15750.	16000.	16500.
16750.	17000.	17000.	17000.	17000.	17000.	16800.
17000.	17000.	17000.	17000.	16700.	16250.	15500.
15000.	14000.	13250.	12000.	11200.	10500.	10200.
10500.	11700.	14200.	17000.	19500.	21500.	23700.
26500.	30000.	34000.	40000.	45500.	50000.	53000.
55200.	58300.	61500.	65000.	68500.	70750.	71600.
71500.	70600.	69000.	66000.	62500.	59000.	55500.
51750.	48000.	45200.	42000.	39500.	37000.	33750.
30750.	28500.	26000.	22600.	22100.	23000.	22500.
21500.	20750.	20000.	19500.	19000.	18750.	18500.
18000.	17500.	17000.	16500.	16250.	16000.	16000.
16000.	16000.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M= 2

333.	330.	400.	500.	500.	550.	750.
1250.	2250.	4000.	6500.	9000.	11500.	13000.
14000.	14500.	15000.	15500.	15750.	16000.	16500.
16750.	17000.	17000.	17000.	17000.	17000.	16800.
17000.	17000.	17000.	17000.	16700.	16250.	15500.
15000.	14000.	13250.	12000.	11200.	10500.	10200.
10500.	11700.	14200.	17000.	19500.	21500.	23700.
26500.	30000.	34000.	40000.	45500.	50000.	53000.
55200.	58300.	61500.	65000.	68500.	70750.	71600.
71500.	70600.	69000.	66000.	62500.	59000.	55500.
51750.	48000.	45200.	42000.	39500.	37000.	33750.
30750.	28500.	26000.	22600.	22100.	23000.	22500.
21500.	20750.	20000.	19500.	19000.	18750.	18500.
18000.	17500.	17000.	16500.	16250.	16000.	16000.
16000.	16000.					

SUM= 2541213. -SUM= 0. -MAX= 0.

COMPUTED LOCAL FLOW

M=	3	295.	300.	296.	625.	949.	3356.	5739.
		8050.	10205.	13902.	17209.	18730.	19960.	20546.
		21247.	21109.	21191.	19489.	17942.	16543.	15225.
		13967.	12785.	11692.	10696.	9974.	9307.	8706.
		8130.	7523.	6937.	6365.	5843.	5088.	4458.
		3928.	3505.	3118.	2846.	2393.	2488.	3223.
		3788.	10289.	16282.	22344.	27968.	31663.	35223.
		39733.	43852.	48008.	51563.	60030.	68219.	75128.
		82599.	78294.	75028.	71240.	67400.	61176.	55709.
		50716.	46260.	42886.	40195.	36595.	33630.	29988.
		26765.	24072.	21731.	19894.	18023.	16039.	14064.
		13457.	12866.	12187.	11535.	11942.	11613.	10738.
		9707.	9918.	10035.	10050.	9957.	10151.	10230.
		10244.	10241.	9865.	9488.	9081.	8620.	8387.
		8070.	7688.					

.OCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	3	295.	300.	296.	625.	949.	3356.	5739.
		8050.	10205.	13902.	17209.	18730.	19960.	20546.
		21247.	21109.	21191.	19489.	17942.	16543.	15225.
		13967.	12785.	11692.	10696.	9974.	9307.	8706.
		8130.	7523.	6937.	6365.	5843.	5088.	4458.
		3928.	3505.	3118.	2846.	2393.	2488.	3223.
		3788.	10289.	16282.	22344.	27968.	31663.	35223.
		39733.	43852.	48008.	51563.	60030.	68219.	75128.
		82599.	78294.	75028.	71240.	67400.	61176.	55709.
		50716.	46260.	42886.	40195.	36595.	33630.	29988.
		26765.	24072.	21731.	19894.	18023.	16039.	14064.
		13457.	12866.	12187.	11535.	11942.	11613.	10738.
		9707.	9918.	10035.	10050.	9957.	10151.	10230.
		10244.	10241.	9865.	9488.	9081.	8620.	8387.
		8070.	7688.					

SUM= 2078339. -SUM= 0. -MAX= 0.

COMPUTED LOCAL FLOW

M= 2

3310.	3310.	3310.	3310.	3310.	3310.	3310.
3310.	3310.	3360.	3480.	4580.	5680.	7670.
9660.	11630.	13600.	14600.	15600.	16750.	17900.
19675.	21450.	23225.	25000.	28400.	31800.	35200.
38600.	40700.	42800.	43100.	42600.	40575.	38550.
36525.	34500.	32300.	30100.	28350.	26600.	25350.
24100.	23200.	22300.	22125.	21950.	21775.	21600.
21500.	21400.	21300.	21200.	21175.	21150.	21125.
21100.	21300.	21500.	21700.	21900.	22000.	22100.
22000.	21900.	21650.	21400.	20850.	20300.	19600.
18900.	18200.	17500.	17013.	16525.	16037.	15550.
15063.	14575.	14087.	13600.	13275.	12950.	12625.
12300.	11850.	11400.	10620.	9840.	8860.	7880.
7215.	6550.	6283.	6015.	5747.	5500.	5300.
5100.	4900.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M= 2

3310.	3310.	3310.	3310.	3310.	3310.	3310.
3310.	3310.	3360.	3480.	4580.	5680.	7670.
9660.	11630.	13600.	14600.	15600.	16750.	17900.
19675.	21450.	23225.	25000.	28400.	31800.	35200.
38600.	40700.	42800.	43100.	42600.	40575.	38550.
36525.	34500.	32300.	30100.	28350.	26600.	25350.
24100.	23200.	22300.	22125.	21950.	21775.	21600.
21500.	21400.	21300.	21200.	21175.	21150.	21125.
21100.	21300.	21500.	21700.	21900.	22000.	22100.
22000.	21900.	21650.	21400.	20850.	20300.	19600.
18900.	18200.	17500.	17013.	16525.	16037.	15550.
15063.	14575.	14087.	13600.	13275.	12950.	12625.
12300.	11850.	11400.	10620.	9840.	8860.	7880.
7215.	6550.	6283.	6015.	5747.	5500.	5300.
5100.	4900.					

SUM= 1786160. -SUM= 0. -MAX= 0.

COMPUTED LOCAL FLOW

M=	3	1900.	1900.	1900.	1900.	1900.	1900.	1900.
		1900.	1900.	2164.	2548.	2787.	4136.	8576.
		11693.	13843.	15815.	15723.	15740.	14271.	12832.
		11337.	9724.	9220.	8649.	8469.	7860.	7718.
		7365.	6427.	5667.	5274.	5491.	4762.	4788.
		4624.	4873.	4752.	4896.	4728.	4604.	4397.
		4101.	4043.	3857.	4282.	4473.	6340.	8080.
		9414.	10662.	10095.	9481.	8821.	8119.	7384.
		6626.	6321.	5953.	5837.	5686.	5523.	5363.
		5131.	4947.	3167.	3247.	3411.	3675.	4033.
		4480.	4992.	5528.	5015.	4487.	3947.	3398.
		2843.	2283.	1720.	1153.	1001.	813.	597.
		361.	124.	-98.	-267.	-356.	-171.	101.
		401.	684.	905.	1027.	1077.	1071.	1050.
		985.	886.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	3	1897.	1897.	1897.	1897.	1897.	1897.	1897.
		1897.	1897.	2160.	2543.	2782.	4129.	8561.
		11672.	13818.	15786.	15694.	15711.	14245.	12809.
		11317.	9706.	9203.	8634.	8453.	7846.	7704.
		7352.	6415.	5657.	5265.	5481.	4753.	4780.
		4616.	4865.	4743.	4887.	4719.	4596.	4389.
		4093.	4036.	3850.	4274.	4465.	6329.	8065.
		9397.	10643.	10077.	9464.	8805.	8104.	7371.
		6614.	6310.	5942.	5826.	5676.	5513.	5353.
		5122.	4938.	3162.	3242.	3405.	3668.	4025.
		4472.	4983.	5518.	5005.	4479.	3940.	3392.
		2837.	2279.	1717.	1151.	1000.	812.	596.
		360.	123.	0.	0.	0.	0.	101.
		401.	683.	903.	1025.	1075.	1069.	1048.
		983.	885.					

SUM= 490964. -SUM= -892. -MAX= -356.

COMPUTED LOCAL FLOW

M= 2

3160.	3093.	3025.	2940.	3020.	3207.	3800.
4660.	5650.	7203.	8395.	9653.	11400.	13300.
15200.	17075.	18600.	20150.	21700.	23575.	25800.
31250.	42800.	64650.	99900.	126000.	140000.	143000.
138000.	130500.	120500.	110500.	103000.	94300.	85500.
76950.	69000.	63100.	57200.	52350.	47500.	43950.
40400.	37300.	34200.	31750.	29300.	27550.	25800.
24450.	23100.	22000.	20900.	19950.	19000.	18300.
17600.	17150.	16700.	16500.	16300.	16225.	16150.
16075.	16000.	15900.	15800.	15650.	15500.	15300.
15100.	14800.	14500.	14125.	13750.	13375.	13000.
12725.	12450.	12175.	11900.	11600.	11300.	11000.
10750.	10500.	10250.	10000.	9750.	9500.	9250.
9000.	8750.	8500.	8250.	8000.	7750.	7500.
7250.	7000.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M= 2

3160.	3093.	3025.	2940.	3020.	3207.	3800.
4660.	5650.	7203.	8395.	9653.	11400.	13300.
15200.	17075.	18600.	20150.	21700.	23575.	25800.
31250.	42800.	64650.	99900.	126000.	140000.	143000.
138000.	130500.	120500.	110500.	103000.	94300.	85500.
76950.	69000.	63100.	57200.	52350.	47500.	43950.
40400.	37300.	34200.	31750.	29300.	27550.	25800.
24450.	23100.	22000.	20900.	19950.	19000.	18300.
17600.	17150.	16700.	16500.	16300.	16225.	16150.
16075.	16000.	15900.	15800.	15650.	15500.	15300.
15100.	14800.	14500.	14125.	13750.	13375.	13000.
12725.	12450.	12175.	11900.	11600.	11300.	11000.
10750.	10500.	10250.	10000.	9750.	9500.	9250.
9000.	8750.	8500.	8250.	8000.	7750.	7500.
7250.	7000.					

SUM= 2989206. -SUM= 0. -MAX= 0.

COMPUTED LOCAL FLOW

M=	3	1420.	1297.	1188.	1185.	1355.	2773.	4452.
		6153.	7933.	9998.	12430.	15211.	17898.	19571.
		21583.	23503.	24830.	24946.	25256.	25183.	25197.
		25224.	23618.	20245.	13821.	12886.	20095.	31515.
		44118.	51741.	51872.	47675.	40093.	30759.	22576.
		14344.	7355.	3006.	-1260.	-2162.	-2451.	-1983.
		-2004.	-661.	355.	1103.	1344.	1662.	1643.
		1886.	1754.	1311.	606.	938.	1092.	1082.
		919.	1110.	1129.	1316.	1382.	1543.	1732.
		1912.	2039.	1740.	1916.	2079.	2240.	2403.
		2576.	2768.	2987.	635.	915.	1218.	1539.
		1861.	2172.	2473.	2768.	461.	756.	1052.
		1343.	1624.	1897.	2164.	2427.	787.	1045.
		1300.	1554.	1808.	2060.	2312.	2563.	214.
		465.	715.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	3	1402.	1281.	1173.	1169.	1338.	2738.	4395.
		6074.	7831.	9870.	12271.	15017.	17669.	19320.
		21306.	23201.	24512.	24626.	24932.	24860.	24874.
		24900.	23315.	19986.	13644.	12721.	19837.	31111.
		43552.	51078.	51207.	47064.	39579.	30365.	22286.
		14160.	7260.	2968.	0.	0.	0.	0.
		0.	0.	350.	1089.	1327.	1641.	1622.
		1862.	1731.	1294.	598.	926.	1078.	1068.
		907.	1095.	1114.	1299.	1365.	1523.	1710.
		1887.	2013.	1718.	1892.	2053.	2211.	2373.
		2543.	2733.	2949.	627.	903.	1202.	1519.
		1837.	2144.	2441.	2733.	455.	746.	1039.
		1326.	1603.	1873.	2137.	2396.	777.	1031.
		1284.	1534.	1784.	2034.	2282.	2530.	211.
		459.	706.					

SUM= 810477. -SUM= -10521. -MAX= -2451.

EXAMPLE 3 INPUT

```
T1EXAMPLE 3     MUSKINGUM ROUTING OPTIMIZATION USER SPECIFIED NO. OF SUBREACHES
T2    SCIOTO RIVER  CHILLICOTHE TO HIGBY OHIO
T3    SINGLE EVENT - JANUARY 1959
J1    100       3       0       0       1       0       0       0       1       1
ID CHILLICOTHE TO HIGBY - JAN 1959
RT      2       3     3.6       0       0       0       6       3       3       0
IN      2   JAN59
QO   3160    3093    3025    2940    3020    3207    3800    4660    5650    7203
QO   8395    9653   11400   13300   15200   17075   18600   20150   21700   23575
QO  25800   31250   42800   64650   99900  126000  140000  143000  138000  130500
QO 120500  110500  103000   94300   85500   76950   69000   63100   57200   52350
QO  47500   43950   40400   37300   34200   31750   29300   27550   25800   24450
QO  23100   22000   20900   19950   19000   18300   17600   17150   16700   16500
QO  16300   16225   16150   16075   16000   15900   15800   15650   15500   15300
QO  15100   14800   14500   14125   13750   13375   13000   12725   12450   12175
QO  11900   11600   11300   11000   10750   10500   10250   10000    9750    9500
QO   9250    9000    8750    8500    8250    8000    7750    7500    7250    7000
IN      3   JAN59
QO   4580    4449    4317    4277    4420    5850    7635    9595   11800   14500
QO  17750   21450   25200   28125   31550   35000   37900   39580   41450   42975
QO  44700   47050   49400   53300   59400   74850   97350  121000  143000  156500
QO 160000  157000  149000  138000  127000  115000  103000   93200   83400   76850
QO  70300   64950   59600   55550   51500   47750   44000   40750   37500   34950
QO  32400   29850   27300   26000   24700   23400   22100   21300   20500   20000
QO  19500   19200   19025   18912   18800   18300   18300   18300   18300   18300
QO  18300   18300   18300   15700   15700   15700   15700   15700   15700   15700
QO  15700   13100   13100   13100   13100   13100   13100   13100   13100   11200
QO  11200   11200   11200   11200   11200   11200   11200    8600    8600    8600
```

EXAMPLE 3 OUTPUT

ROUTING OPTIMIZATION INPUT DATA

```
T1EXAMPLE 3     MUSKINGUM ROUTING OPTIMIZATION USER SPECIFIED NO. OF SUBREACHES
T2    SCIOTO RIVER  CHILLICOTHE TO HIGBY OHIO
T3    SINGLE EVENT - JANUARY 1959

        NPER      IPER     INPUT     IPRNT     IPLOT    IPUNCH    NFLOOD     NPTSQ     ICURV     IFLOW
J1       100         3         0         0         1         0         0         0         1         1

ID CHILLICOTHE TO HIGBY - JAN 1959

        RTFR      RTTO      RTMD     RTCOF     XMUSK       LAG       WT1       WT2       WT3    METRIC
RT      2.00      3.00      3.60       0.        0.        0.       6.00      3.00      3.00      0.
IN         2       JAN59
   3160.00   3093.00   3025.00   2940.00   3020.00   3207.00   3800.00   4660.00   5650.00   7203.00
   8395.00   9653.00  11400.00  13300.00  15200.00  17075.00  18600.00  20150.00  21700.00  23575.00
  25800.00  31250.00  42800.00  64650.00  99900.00 126000.00 140000.00 143000.00 138000.00 130500.00
 120500.00 110500.00 103000.00  94300.00  85500.00  76950.00  69000.00  63100.00  57200.00  52350.00
  47500.00  43950.00  40400.00  37300.00  34200.00  31750.00  29300.00  27550.00  25800.00  24450.00
  23100.00  22000.00  20900.00  19950.00  19000.00  18300.00  17600.00  17150.00  16700.00  16500.00
  16300.00  16225.00  16150.00  16075.00  16000.00  15900.00  15800.00  15650.00  15500.00  15300.00
  15100.00  14800.00  14500.00  14125.00  13750.00  13375.00  13000.00  12725.00  12450.00  12175.00
  11900.00  11600.00  11300.00  11000.00  10750.00  10500.00  10250.00  10000.00   9750.00   9500.00
   9250.00   9000.00   8750.00   8500.00   8250.00   8000.00   7750.00   7500.00   7250.00   7000.00
IN         3       JAN59
   4580.00   4449.00   4317.00   4277.00   4420.00   5850.00   7635.00   9595.00  11800.00  14500.00
  17750.00  21450.00  25200.00  28125.00  31550.00  35000.00  37900.00  39580.00  41450.00  42975.00
  44700.00  47050.00  49400.00  53300.00  59400.00  74850.00  97350.00 121000.00 143000.00 156500.00
 160000.00 157000.00 149000.00 138000.00 127000.00 115000.00 103000.00  93200.00  83400.00  76850.00
  70300.00  64950.00  59600.00  55550.00  51500.00  47750.00  44900.00  40750.00  37500.00  34950.00
  32400.00  29850.00  27300.00  26000.00  24700.00  23400.00  22100.00  21300.00  20500.00  20000.00
  19500.00  19200.00  19025.00  18912.00  18800.00  18300.00  18300.00  18300.00  18300.00  18300.00
  18300.00  18300.00  18300.00  15700.00  15700.00  15700.00  15700.00  15700.00  15700.00  15700.00
  15700.00  13100.00  13100.00  13100.00  13100.00  13100.00  13100.00  13100.00  13100.00  11200.00
  11200.00  11200.00  11200.00  11200.00  11200.00  11200.00  11200.00   8600.00   8600.00   8600.00
```

OPTIMIZATION ROUTINE OUTPUT

NEG LOCAL	COMPUTED ERRORS: TOO EARLY	TOO LATE	TOTAL
-2397955.45	0.	-1198977.72	-3596933.17
-2438071.15	0.	-1219035.58	-3657106.73
-2805310.22	0.	-1402655.11	-4207965.34
-1958007.04	0.	-979003.52	-2937010.55
-1484828.73	0.	-742414.36	-2227243.09
-966220.93	0.	-483110.47	-1449331.40
-417908.23	0.	-208954.12	-626862.35
-31046.52	0.	-15523.26	-46569.77
0.	-57201.35	0.	-57201.35
-30847.67	0.	-15423.83	-46271.50
-30174.95	0.	-15087.47	-45262.42
-29041.42	0.	-14520.71	-43562.13
-27471.71	0.	-13735.86	-41207.57
-25501.55	0.	-12750.78	-38252.33
-23334.28	0.	-11667.14	-35001.42
-21903.47	0.	-10951.73	-32855.20
0.	-70563.46	0.	-70563.46
-43657.20	0.	-21828.60	-65485.79
-8760.12	0.	-4380.06	-13140.18
-2983.11	-137.96	-1491.56	-4612.63
0.	-1990.79	0.	-1990.79
0.	-6724.15	0.	-6724.15
0.	-2882.29	0.	-2882.29
0.	-1134.71	0.	-1134.71
0.	-455.11	0.	-455.11
0.	-159.54	0.	-159.54
0.	0.	0.	0.

MUSKINGUM OPTIMIZATION COMPLETED

MUSKINGUM K (HOURS PER SUBREACH) = 3.70
MUSKINGUM X = .15
NUMBER OF ROUTING SUBREACHES = 3

UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

M= 2

3160.	3093.	3025.	2940.	3020.	3207.	3800.
4660.	5650.	7203.	8395.	9653.	11400.	13300.
15200.	17075.	18600.	20150.	21700.	23575.	25800.
31250.	42800.	64650.	99900.	126000.	140000.	143000.
138000.	130500.	120500.	110500.	103000.	94300.	85500.
76950.	69000.	63100.	57200.	52350.	47500.	43950.
40400.	37300.	34200.	31750.	29300.	27550.	25800.
24450.	23100.	22000.	20900.	19950.	19000.	18300.
17600.	17150.	16700.	16500.	16300.	16225.	16150.
16075.	16000.	15900.	15800.	15650.	15500.	15300.
15100.	14800.	14500.	14125.	13750.	13375.	13000.
12725.	12450.	12175.	11900.	11600.	11300.	11000.
10750.	10500.	10250.	10000.	9750.	9500.	9250.
9000.	8750.	8500.	8250.	8000.	7750.	7500.
7250.	7000.					

SUM= 2989205.

ROUTED Q FROM MX= 2 TO 3
RTMD= 3.20 RTCOF= .15 K= 3.70

COEF= .00842 .06388 .18416 .25859 .20828 .13217 .07354 .03765 .01816 .00820
.00334 .00127 .00046

M= 3

3160.	3159.	3155.	3137.	3103.	3062.	3049.
3117.	3336.	3764.	4427.	5327.	6414.	7625.
8981.	10512.	12190.	13942.	15683.	17366.	19018.
20744.	22855.	26184.	32353.	43514.	60853.	82315.
103143.	119199.	128541.	131387.	129153.	123577.	115307.
108337.	100016.	91582.	83334.	75617.	68623.	62344.
56737.	51767.	47389.	43491.	39981.	36814.	33981.
31479.	29299.	27402.	25749.	24292.	22995.	21825.
20765.	19814.	18977.	18258.	17662.	17187.	16829.
16569.	16387.	16255.	16150.	16055.	15937.	15848.
15721.	15572.	15397.	15189.	14941.	14654.	14331.
13986.	13633.	13290.	12970.	12669.	12378.	12090.
11799.	11508.	11224.	10951.	10688.	10431.	10178.
9926.	9676.	9425.	9175.	8925.	8675.	9425.
8175.	7925.					

SUM= 2973350.

PLOTTED POINTS(BY PRIORITY)-R=INFLOW AT MX ROUTED TO MY, N=OBS OR NAT AT MY, L=LOCAL (INC) AT MY, I=INFLOW AT MX

UPSTREAM(MX) = 2 DOWNSTREAM(MY) = 3

CHILLICOTHE TO HIGBY - JAN 1959

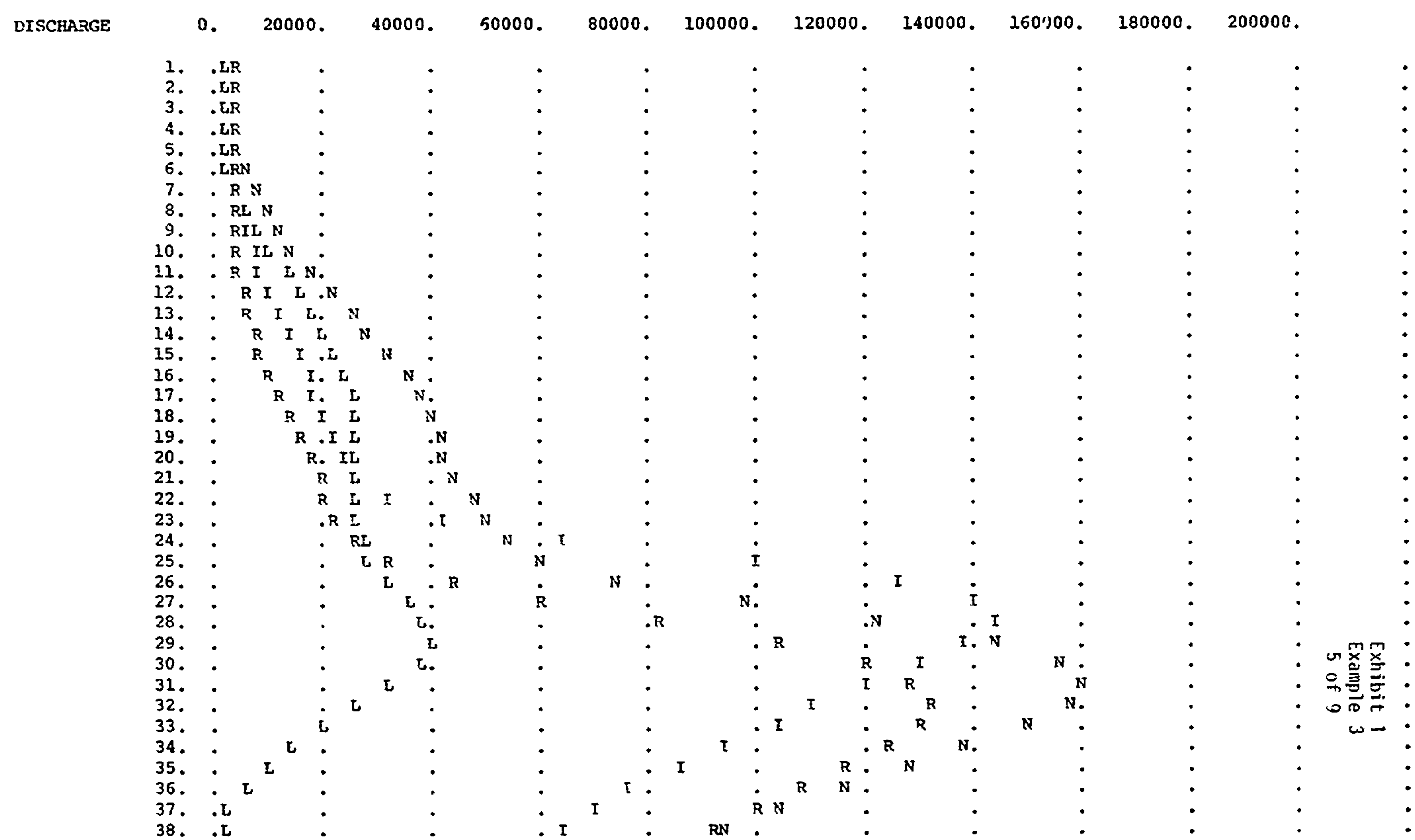


Exhibit 1
Example 3
6 of 9

```
39.  L          .         .        I.         . R       .         .         .         .         .         .
40.  .L         .         .     I   .       R .         .         .         .         .         .         .
41.  .L         .         .   I     .  RN     .         .         .         .         .         .         .
42.  .L         .         . I       .RN       .         .         .         .         .         .         .
43.  .L         .         I       R N         .         .         .         .         .         .         .
44.  . L        .        I.     R N .         .         .         .         .         .         .         .
45.  . L        .      I  .   R N   .         .         .         .         .         .         .         .
46.  . L        .     I   . R N     .         .         .         .         .         .         .         .
47.  . L        .    I    R N       .         .         .         .         .         .         .         .
48.  . L        .   I   R N         .         .         .         .         .         .         .         .
49.  . L        .  I   R N.         .         .         .         .         .         .         .         .
50.  . L        . I   RN  .         .         .         .         .         .         .         .         .
51.  . L        . I  RN   .         .         .         .         .         .         .         .         .
52.  .L         .I  RN    .         .         .         .         .         .         .         .         .
53.  .L         I  RN     .         .         .         .         .         .         .         .         .
54.  .L         I RN      .         .         .         .         .         .         .         .         .
55.  .L         IRN       .         .         .         .         .         .         .         .         .
56.  .L        I.RN       .         .         .         .         .         .         .         .         .
57.  .L        IRN        .         .         .         .         .         .         .         .         .
58.  .L        IRN        .         .         .         .         .         .         .         .         .
59.  .L       IRN         .         .         .         .         .         .         .         .         .
60.  .L       IRN         .         .         .         .         .         .         .         .         .
61.  .L       IRN         .         .         .         .         .         .         .         .         .
62.  .L       IRN         .         .         .         .         .         .         .         .         .
63.  .L       R N         .         .         .         .         .         .         .         .         .
64.  .L       RN.         .         .         .         .         .         .         .         .         .
65.  .L       RN.         .         .         .         .         .         .         .         .         .
66.  .L       RN.         .         .         .         .         .         .         .         .         .
67.  .L       RN.         .         .         .         .         .         .         .         .         .
68.  .L       RN.         .         .         .         .         .         .         .         .         .
69.  .L       RN.         .         .         .         .         .         .         .         .         .
70.  .L       RN.         .         .         .         .         .         .         .         .         .
71.  .L       RN.         .         .         .         .         .         .         .         .         .
72.  .L      IRN.         .         .         .         .         .         .         .         .         .
73.  .L      IRN.         .         .         .         .         .         .         .         .         .
74.  L       IR .         .         .         .         .         .         .         .         .         .
75.  L       RN .         .         .         .         .         .         .         .         .         .
76.  .L      RN .         .         .         .         .         .         .         .         .         .
77.  .L      RN .         .         .         .                   .         .         .         .         .         .
78.  .L     IRN .         .         .         .         .         .         .         .         .         .
79.  .L     IRN .         .         .         .         .         .         .         .         .         .
80.  .L     IRN .         .         .         .         .         .         .         .         .         .
81.  .L     R N .         .         .         .         .         .         .         .         .         .
82.  L      RN  .         .         .         .         .         .         .         .         .         .
83.  L      RN  .         .         .         .         .         .         .         .         .         .
84.  .L     RN  .         .         .         .         .         .         .         .         .         .
85.  .L    IRN  .         .         .         .         .         .         .         .         .         .
86.  .L    IRN  .         .         .         .         .         .         .         .         .         .
```

```
 87.  .L   IRN  .   .   .   .   .   .   .   .   .   .   .
 88.  .L   R N  .   .   .   .   .   .   .   .   .   .   .
 89.  .L   R N  .   .   .   .   .   .   .   .   .   .   .
 90.  L    RN   .   .   .   .   .   .   .   .   .   .   .
 91.  .L   RN   .   .   .   .   .   .   .   .   .   .   .
 92.  .L   RN   .   .   .   .   .   .   .   .   .   .   .
 93.  .L  IRN   .   .   .   .   .   .   .   .   .   .   .
 94.  .L  IRN   .   .   .   .   .   .   .   .   .   .   .
 95.  .L  IRN   .   .   .   .   .   .   .   .   .   .   .
 96.  .L  R N   .   .   .   .   .   .   .   .   .   .   .
 97.  .L  R N   .   .   .   .   .   .   .   .   .   .   .
 98.  L   R     .   .   .   .   .   .   .   .   .   .   .
 99.  L   R     .   .   .   .   .   .   .   .   .   .   .
100.  L   R     .   .   .   .   .   .   .   .   .   .   .
```

INC LOCAL FLOWS COMPUTED

COMPUTED LOCAL FLOW

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

SUM= 2989206. -SUM= 0. -MAX= 0.

COMPUTED LOCAL FLOW

```
M=      3                1420.   1290.   1162.   1140.   1317.   2788.   4586.
                         6478.   8464.  10736.  13323.  16123.  18786.  20500.
                        22569.  24488.  25710.  25638.  25767.  25609.  25682.
                        26306.  26545.  27116.  27047.  31336.  36497.  38685.
                        39857.  37301.  31459.  25613.  19847.  14423.  10693.
                         6663.   2984.   1618.     66.   1233.   1677.   2606.
                         2863.   3783.   4111.   4259.   4019.   3936.   3519.
                         3471.   3101.   2448.   1551.   1708.   1705.   1575.
                         1334.   1486.   1523.   1742.   1838.   2013.   2196.
                         2343.   2413.   2045.   2150.   2245.   2343.   2452.
                         2579.   2728.   2903.    511.    759.   1046.   1369.
                         1714.   2067.   2410.   2730.    431.    722.   1010.
                         1301.   1592.   1876.   2149.   2412.    769.   1022.
                         1274.   1524.   1775.   2025.   2275.   2525.    175.
                          425.    675.
```

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

```
M=      3                1420.   1290.   1162.   1140.   1317.   2788.   4586.
                         6478.   8464.  10736.  13323.  16123.  18786.  20500.
                        22569.  24488.  25710.  25638.  25767.  25609.  25682.
                        26306.  26545.  27116.  27047.  31336.  36497.  38685.
                        39857.  37301.  31459.  25613.  19847.  14423.  10693.
                         6663.   2984.   1618.     66.   1233.   1677.   2606.
                         2863.   3783.   4111.   4259.   4019.   3936.   3519.
                         3471.   3101.   2448.   1551.   1708.   1705.   1575.
                         1334.   1486.   1523.   1742.   1838.   2013.   2196.
                         2343.   2413.   2045.   2150.   2245.   2343.   2452.
                         2579.   2728.   2903.    511.    759.   1046.   1369.
                         1714.   2067.   2410.   2730.    431.    722.   1010.
                         1301.   1592.   1876.   2149.   2412.    769.   1022.
                         1274.   1524.   1775.   2025.   2275.   2525.    175.
                          425.    675.
SUM=   810090. -SUM=         0. -MAX=         0.
```

EXHIBIT 2

INPUT DESCRIPTION

Streamflow Routing Optimization (OPROUT)

To determine the optimization routing criteria using modified Puls or Muskingum routing methods for a single reach, at least one set of observed hydrographs are required for the upstream and downstream ends of the reach. A maximum of five sets of observed hydrographs can be used to develop the routing criteria. The observed upstream hydrograph must be input ahead of the downstream hydrograph for each event. There is a date variable on the input cards so that the starting date of each flood can be input with the flow data.

If several floods are used to develop the routing criteria, all the flow data must have the same number of periods. This means shorter events must be extended with base flow values up to the number of periods of the longest event. The added data should be included at the end of the actual flood and the upstream values generally should be less than the downstream values.

The following INPUT DESCRIPTION provides a detailed description of data input. Input format is the standard HEC ten fields of 8 columns each with the first two card columns reserved for the card identification. Card ID is not read by the program. Three title cards are used to provide labeling information. The job card defines job options using integers (no decimal points). The identification card provides a label for plots, and the routing card provides the routing optimization information. The remaining cards contain the flow data (upstream then downstream hydrograph).

INPUT DESCRIPTION

Streamflow Routing Optimization Program (OPROUT)

T1, T2, T3 Cards - Title Cards

Job title cards; three cards required. Both alphabetic and numberic information may be placed on these cards. Information on these cards will be printed out as job title on the first page of output.

J1 Card - Job Card - all integers

Field	Variable	Value	Description
1	NPER	+	Number of values on each set of flow data cards (IN). Each set of flow data must have NPER Values (300 maximum).
2	IPER	+	Time interval (Δt) in hours between flow values.
3	INPUT	0	First input card for each flow set will have control point number in field 1 and date in field 2 and no other data. Subsequent cards contain 10 fields of flow data.
		5	Flow data will be in default HEC-5 format. First two fields of first card are for control point and date with flow data on the remaining 8 fields. Subsequent cards contain 10 fields of flow data.

J1 Card - Continued

Field	Variable	Value	Description
4	IPRNT	0	Output will be limited to Input Data, Optimization Errors, and optimization results.
		1	Same as above plus optimization trace.
		15	Same as above plus routing trace.
		20	Same as above plus detailed routing trace.
5	IPLOT	0	No hydrograph plot.
		1	Plot hydrograph for Inflow (Routed Downstream), Observed flow downstream, Computed Local Flow, and Inflow Upstream.
6	IPUNCH	0	No punch cards.
		1	Punch computed local flow data.
7	NFLOOD	0	One flood event will be used to optimize routing criteria.
		+	Number of flood events (5 maximum) requires upstream and downstream flow data for each event.
8	NPTSQ	0	Number of storage-outflow points to be derived from optimization routing is equal to 9.
		+	Number of storage-outflow points to be derived (18 maximum). The more points used, the longer the optimization time.
9	ICURV	0	No adjustments will be made to the storage-outflow curve (UNSMOOTHED CURVE).

J1 Card - Continued

Field	Variable	Value	Description
		+	A fourth order polynomial curve should be fitted to the unsmoothed curve. The smooth curve will then be used for computing local flows.
10	IFLOW	0	Input flow data is average for the period.
		1	Input flow data is end of period data. Flow data will be averaged before routing.

ID Card - Identification Card for Reach

Field	Variable	Value	Description
1- 5	CPT(K)	+	Title (alphanumeric) of routing reach in columns 3-40. Title will be printed on hydrograph plots.
6-10	Not used		

RT Card - Routing Card

Field	Variable	Value	Description
1	RTFR	+	Control point number of upstream end of routing reach.
2	RTTO	+	Control point number of downstream end of routing reach.
3	RTMD	+	Number of subreaches to the left of the decimal and routing method to the right of the decimal (.5 for modified Puls and .6 for Muskingum). If subreaches are not given, the number will be optimized.

RT Card - Continued

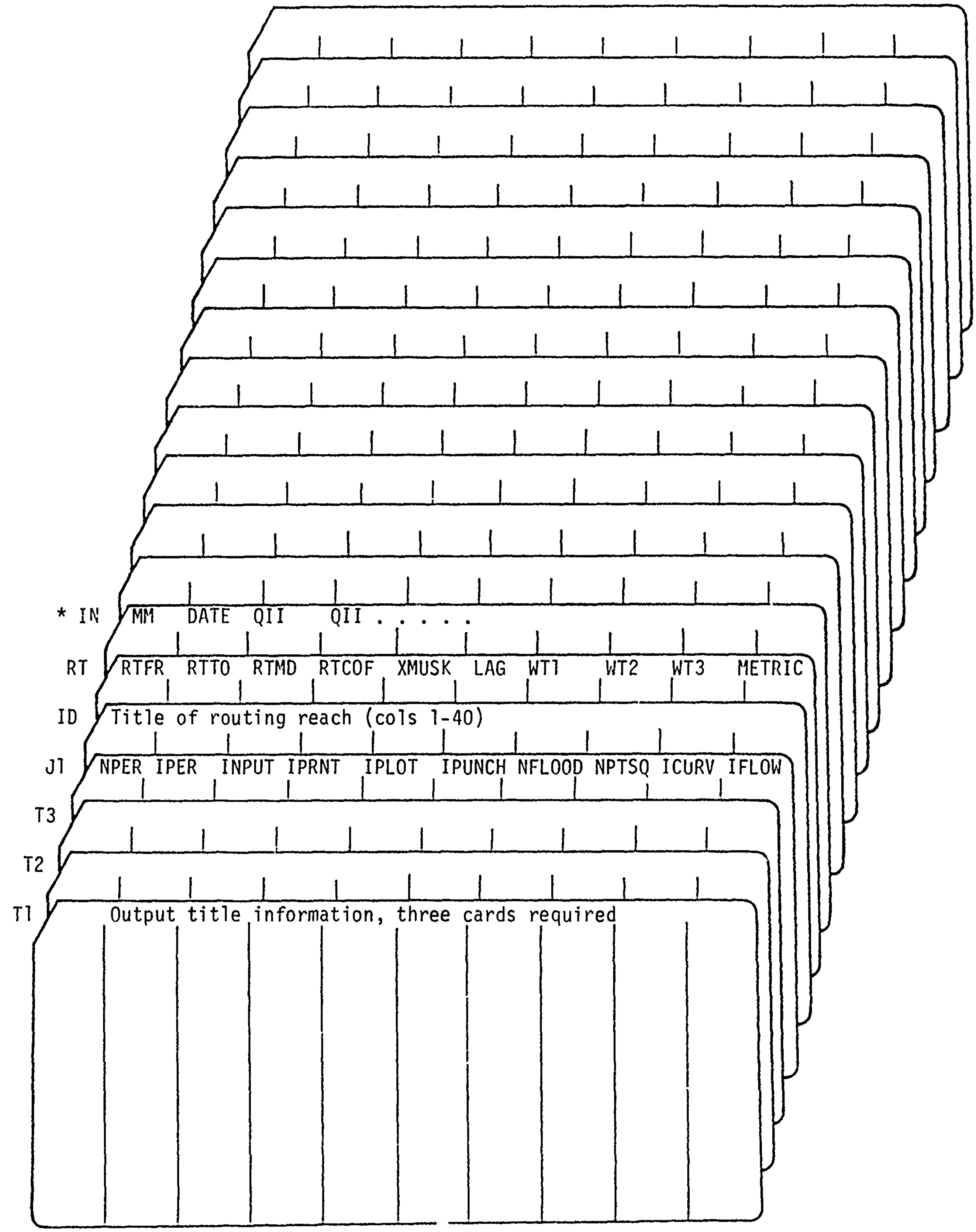
Field	Variable	Value	Description
4	RTCOF	0	Muskingum routing coefficient "X" will be optimized if Muskingum optimization is requested (RT.3 = .6).
		+	Coefficient X will not be optimized. The given value will be used for Muskingum or modified Puls.
5	XMUSK	0	Travel time (Muskingum K) in hours will be optimized if Muskingum optimization is requested.
6	LAG	0	No lag in addition to routing.
		±	In addition to routing, lag outflow by the number of periods shown.
7	WT1	0	Weighting of negative local flow equals one (1.0).
		+	Weighting factor for negative local flow. Use any number.
8	WT2	0	Weighting factor (penalty) for recession leg being too early equals zero (0).
		+	Weighting factor for recession leg being too early. (Suggested value near 1.0.)
9	WT3	0	Weighting factor of error on recession leg of hydrograph being too late equals zero (0).
		+	Weighting factor for recession leg being too late. Use in conjunction with WT2. (Suggested value near 4.0.)
10	METRIC	0	English units.
		+	Metric units.

IN Cards - Flow data for upstream and then downstream station.*

Field	Variable	Value	Description
1	MM	+	Control point number for input hydrograph. First hydrograph for the upstream location, and then the downstream location.
2	DATE	+	Starting date of flow data for identification only. Can be alphanumeric data.
3-10	QII	+	Flow data in cfs or m^3/SEC if INPUT (J1.3) equals 5. Remaining data starts in field 1 of succeeding cards. (NPER values.)
or			
1-10	QII	+	Flow data starts in field 1 of the second card if INPUT (J1.3) equals 0 (NPER values).

*Repeat IN cards for both control points. Two sets of flow data in turn for each flood up to the number of floods prescribed (NFLOOD on J1.7).

SUMMARY OF INPUT CARDS
STREAMFLOW ROUTING OPTIMIZATION PROGRAM (OPROUT)



*Include IN cards for inflow then outflow of reach for each flood event.